THE

GEOLOGICAL

AND

NATURAL HISTORY

SURVEY OF MINNESOTA.

THE

FIRST ANNUAL REPORT

FOR THE YEAR 1872

By N. H. WINCHELL, State Geologist.

SUBMITTED TO THE PRESIDENT OF THE BOARD OF REGENTS
DECEMBER 31, 1872.

[SECOND EDITION.]

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NOTE.—This edition is identical with the original publication, except in typography, and in the lists of elevations on various railroads, which have been revised and corrected and referred to sea-level, through lake Superior at 602 feet. The pagination begins with number 17, in order to agree with the original.—N. H. WINCHELL.

ADDRESS.

St. Anthony, Minn.,
Dec. 31, 1872.

Hon. J. S. Pillsbury, president of the board of regents of the University of Minnesota:

Dear sir :—I have the honor herewith to present the first annual report of progress on the geological and natural history survey of the state, required by the provisions of the law creating the same. The field work covered by this report is that performed by myself alone between the first of September and the closing of the season, on the 12th day of November, by the first fall of snow. The means at my disposal not admitting of the employment of assistants, it has only been possible to make a general reconnoissance of the state by visiting those parts accessible by railroad. In that way I have succeeded in making a connected section of observed strata from the trap and granite rocks, which lie at the base of our geological system, to the *Galena limestone*, in the Lower Silurian, including also about forty feet of the latter. Between the *Galena* and the *Cretaceous* no intervening rocks have been seen, but it is probable that the remainder of the Lower Silurian, including the *Maquoketa shales* and the *Niagara limestone*, which in the Northwest seems to constitute the Upper Silurian, as well as the lower portions of the Devonian, are in place in some parts of the southern portion of the state. A few sections have also been taken in the *Cretaceous* clays and sandstones in the southern part of the state. Developments of considerable interest and economical importance have already been made in connection with this series of rocks, as detailed in the accompanying report; and it is believed that they

will afford in the future progress of the survey some of the best exemplifications, not only of the scientific value, but also of the practical usefulness of our investigations.

The small geological map of the state accompanying this report is intended to embody all that is known concerning the geographical outlines of the various formations embraced within the state. With the exception of the southeastern part of the state, the outlines of the geology of which have been more minutely laid out by Mr. W. D. Hurlbut, of Rochester, Minn., this map is to be regarded as only an approximation to the actual bearing of the strata, the boundaries of which are marked by tortuosities which it will be the future work of the survey to carefully trace out.

It becomes my pleasant duty to acknowledge the active interest and aid of the president of the university in the initiation of the survey in various matters of administrative courtesy touching its relation to the university. Rooms have been provided in the university building for the storage of specimens and for laboratory work; and the nucleus of a geological museum has already been established.

Mr. W. D. Hurlbut, of Rochester, who, as a pioneer in the scientific development of the geology of southern Minnesota, has gathered information which it would require several seasons of field work for one man to collect, has freely aided me by giving all the information in his possession, and has spent considerable time gratuitously in guiding me to points of interest. The preliminary map accompanying this report shows the minuteness with which he has observed the geological boundaries in that part of the state.

Prof. Wm. F. Phelps, of the normal school at Winona, has given much information concerning that section of the state, and has accompanied me to various places of geological importance. His collection of fossils from the *Trenton* and other Silurian rocks stored in the museum of the normal school, has been opened for examination and study. He has donated to the geological museum of the university plaster casts of some of the largest and most perfect specimens of trilobites ever found in the state of Minnesota.

Mr. A. J. Hill, of St. Paul, has enjoyed unusual facilities for collecting the most complete information concerning the relative altitudes of different parts of the state as shown by railroad profiles, and has tendered to the survey the free use of all his tables.

Dr. H. H. Guthrie, of St. Charles, and Mr. A. Van Vorhes, of Stillwater, guided me in making observations at those places; giving me much valuable information.

Mr. Frank Wilson, of Mantorville, has placed in the university museum a large collection of fossils from the *Galena limestone*, on temporary deposit. For the benefit of the geological survey he has submitted them for examination and nomenclature.

The St. Paul & Sioux City, and Sioux City & St. Paul R. R., the Northern Pacific R. R. and the Southern Minnesota R. R. have materially aided in the prosecution of the field-work by granting continuous passes on their roads. The Winona & St. Peter R. R. has also granted trip passes on application.

In general the people of the state, so far as I have come in contact with them, have manifested much interest in the survey, and expressed a willingness to aid in its progress in every way in their power.

Allow me to thank you for the cordiality with which you have officially counseled and aided me in making the preliminary reconnoissance, and for personal favors at your hands.

Very respectfully,

N. H. WINCHELL,
State Geologist.

I.

HISTORICAL SKETCH AND LIST OF PUBLICATIONS RELATING TO THE GEOLOGY AND NATURAL HISTORY OF MINNESOTA.

The earliest published accounts of the natural features and resources of Minnesota are found in the writings of the Jesuit missionaries. These, however, are generally too vague or too general in their statements to be of much scientific value. The first printed account and distinct mention of the Mississippi river, within the limits ot Minnesota, seems to be that of Father Hennepin, who visited the falls of St. Anthony in 1680, and gave them their name, although Father Marquette discovered the river at lower points as early as 1673. Father Hennepin's book, published at Utrecht in 1679, has the following title: *Voyage ou nouvelle decouverte d' un tres grand pays dans L' Amerique entre nouveau Mexique et la mer glaciale par le R. P. Louis Hennepin, avec toutes les particularitez de ce Pais, & de celui connue sous le nom de La Louisiane; les advantages qu' on en peut tirer par l' etablissement des colonies; enriche de Cartes Geographiques: augmente de quelques figures en taille douce;—avec un voyage qui contiente une Relation exacte de l'Origine, Moeurs, Coutumes, Religion, Guerres, & Voyages des Caraibes sauvages des Isles Antilles de l'Amerique, faite par le Sieur De La Borde, tiree du Cabinet de Monsr. Blondel.*

The voyage proper of Hennepin is divided into seventy-six chapters. The following titles show the relations of some of these chapters to the state of Minnesota.

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XXXVI. Depart d'Auteur en Canot du fort Crevecoeur avec les deux hommes, dont il a ete parle, pour se rendre aux Nations eloignees.

XXXVII. Quels ont ete les motifs que l'Auteur a eus ci-devant de cacher les memoires qu' il avoit de cette Decouverte & de ne les pas inferer dans la Description de sa Louisiane.

XXXVIII. Continuation' du voyage de l'Auteur sur le Fleuve Meschasipi.

XXXIX. Raisons qui nous obligerent de remonter le Fleuve Meschasipi sans aller plus loin vers la Mer.

XL. Depart de Koroa sur le Fleuve Meschasipi.

XLI. Description de la beaute du Fleuve Meschasipi, des terres, qui le bordent de part & d'autre, & qui sont d'un beaute' ravissante & des Mines de cuivre, de plomb, & de carbon de terre qu'on y a trouva.

XLII. Description' des divers langes de ces peuples & de leur soumission a' leurs Chefs; des Mannieres differentes de ces peuples de Meschasipi d'avec les sauvages du Canada & du peu de fruit, qu' on peut esperer pour la Religion chretiene parmi eux.

XLIII. Description de la peche vue nous faissons des etourgeons. Crainte de nos gens qui ne vouloient point passer en remontant pres de l' embouchure de la Riviere des Illinois, & du changement des terres et du climat en allant vers le Nord.

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LIX. Les sauvages sont halte au dessus du saut de St. Antoine de Padoue. Ils se trouvent en necessite de vivres; l' Auteur va avec le Picard a' Riviere d' Ouisconsin. Aventures de leur voyage.

LX. Chasse des Tortues, le canot enleve' a' l' Auteur par un vent impetueux, ce qui le jette dans un grande necessite avec son compagnon de voyage.

Memoire sur les Moeurs, Coutumes, et Religion des sauvages de l' Amerique Septentrionale, par Nicolas Perrot, publie pour la premiere fois, par le R. P. J. Tailhan de la compagne de Jesus, 1864. 12mo. 341 pp.

This valuable memoir remained in manuscript from 1670 till 1864 without publication.

In the latter part of the seventeenth century Baron La Hontan, Lord Lieutenant of the French colony at Placentia, Newfoundland, traveled over much of the Northwest, visiting the territory now embraced in Minnesota, and describing the nations and many of the natural features of the country. His book is entitled: *New Voyages to North America, containing an account of the several na-*

tions of that vast continent, their customs, commerce and way of Navigation upon the Lakes and Rivers; the several attempts of the English and French to dispossess one another, with the relations of the miscarriage of the former; and the various adventures between the French and the Iroquese, confederates of England, from 1683 to 1694.

Historical Collections of Louisiana, embracing translations of many rare and valuable documents relating to the natural, civil and political history of that state. Part IV. Redfield, New York, 1852, 8vo. pp. 268. (map.) Contains original narratives by Marquette, Allouez, Membre, Hennepin and Douay, relating to the discovery and exploration of the Mississippi river.

Early voyages up and down the Mississippi. By Cavalier, St. Cosme, Le Sueur, Gravier and Geugnas, with an introduction and notes by John G. Shea, Albany, 1861, 4to. pp. 191.

The travels of Jonathan Carver were performed in 1766,'67 and '68. His may be regarded the first contribution to the natural history of the country bordering on the upper Mississippi. His work is printed under the title of: *Three Years' Travels throughout the interior parts of North America.* Containing an account of the lakes, islands and rivers, cataracts, mountains, minerals, soil and vegetable productions of the northwest regions of that vast continent, with a description of the birds, beasts, reptiles, insects and fishes peculiar to that country, together with a concise history of the genius, manners and customs of the Indians inhabiting the lands that lie adjacent to the heads and west of the river Mississippi; and an appendix describing the uncultivated parts of America that are the most proper for forming settlements; by Jonathan Carver, captain of the provincial troops in America; 16mo. pp. 280.

Mr. Schoolcraft's first expedition to the sources of the Mississippi river was performed in 1820. His report was published under the following title: *Narrative Journal of travels from Detroit northwest through the great chain of lakes to the sources of the Mississippi river in 1820.* By Henry R. Schoolcraft, performed as a member of the expedition under Governor Cass, embellished with a map and eight copper plate engravings, 8vo. pp. 419.

In the year 1823 the United States Government ordered an expedition to the sources of the St. Peter river, lake Winnepeg and lake of the Woods, the report of which was published by congress under the following title: *Narrative of an expedition to the sources*

of the St. Peter river, lake Winnepeek, lake of the Woods, &c., performed in the year 1823 by order of Hon. J. C. Calhoun, secretary of war, under the command of Stephen H. Long, U. S. topographical engineers. 2 vols., pp. 458 and 248, with an appendix of 156 pages.

CONTENTS OF VOLUME I.

Chapter I. Departure from Philadelphia—Geology of the Alleghanies—Cumberland road—Wheeling.

Chapter II. Zanesville—Salt and iron works—Columbus—Piqua—Indian antiquities—Ohio canals—Fort Wayne.

Chapter III. Description of Fort Wayne and vicinity—Fur trade—Potawotamies.

Chapter IV. Cary mission house—Lake Michigan—Chicago.

Chapter V. Rock river—Menomones—Geology of the country west of lake Michigan—Prairie du Chien—Sauks and Foxes.

Chapter VI. Prairie du Chien—Indian remains—Division of the party—Mississippi—Dacotah villages—Fort St. Anthony falls—River St. Peter.

Chapter VII. Geology of the Mississippi—The expedition ascends the St. Peter's—Character of the country—Arrival at lake Traverse.

Chapter VIII. Account of the Dacotahs, or Sioux Indians—Their division into tribes—Their numbers, language, manners and customs—Notice of Watonwan, principal chief of the Yanktonian tribe—Description of the Columbia Fur Company's establishment at lake Traverse.

CONTENTS OF VOLUME II.

Chapter I. The party leave lake Traverse—They fall in with large herds of buffalo—Observations upon the rovings of this animal—Meeting with a war party of the Wahkpahotas who manifest hostile dispositions—Arrival at Pembina.

Chapter II. Fort Douglas and Lord Selkirk's colony—Bark canoes—Lake Winnepeek—Fort Alexander—River Winnepeek—Rapids—Portages—Fine falls—Lake of the Woods—Northwesternmost point of the Boundary line—Rainy Lake river and lake—Fort—Series of rapids and falls—Dividing ridge—Falls of Kamanatekwoya—Arrival at Fort William.

Chapter III. Account of the Chippewa Indians—Their usages, manners and customs.

Chapter IV. Departure from Fort William—Trap formations on lake Superior—Michipecotton house—Arrival at Sault St. Marie—Conclusion of the journey.

Chapter V. General description of the country traversed by the expedition, designed as a topographical report to the war department, by S. H. Long, U. S. T. E. (Divided into seven chapters.)

CONTENTS OF THE APPENDIX.

Part I. *Natural History.* Zoology by Thomas Say—Catalogue and descriptions. Botany by Lewis D. de Schweinitz.

Part II. *Astronomy.*

Part III. *Meteorology.*

Part IV. *Indian Vocabularies.*

Mons. J. C. Beltrami, who, started out as a member of Major Long's party of exploration to the sources of the St. Peter river, parted from him, and exploring the Mississippi to its source, published his observations under the following title: *La Decouverte des sources dù Mississippi, et de la riviere Sanglante.*

Descriptions du cour entier du Mississippi * * * * *aussique du cour entier d l' Ohio, Observations critico-philosophiques sur les moeurs, la religion, les superstitions, les coutumes, les armes, les chasses, la guerre, la paix, le nombrement, l'origine, &c., &c,, de plusieurs nations indiennes* * * * * * *Preuves evidentes que le Mississippi est la premiere riviere du monde.* Par J. C. Beltrami, Membre de plusieurs academies, 1824, pp. 327.

Narrative of an expedition through the Upper Mississippi to Itasca lake, the actual source of this river, embracing an exploratory trip through the St. Croix and Burntwood (or Brule) rivers in 1832, under the direction of Henry R. Schoolcraft. (Published by Harper & Brothers,) pp. 307, 8vo.

Besides the narrative this book embraces an appendix, as follows:

I. *Natural History.* 1. List of shells collected by Mr. Schoolcraft. By William Cooper. 2. Localities of minerals observed in 1831 and 1832 in the Northwest. By H. R. Schoolcraft. 3. Localities of plants collected in the northwestern expeditions of 1831 and 1832. By Douglass Houghton, M. D., surgeon to the expedition.

II. *Indian languages.* Part of a course of lectures on the grammatical structure of the Indian languages, delivered before the St. Mary's committee of the Algic society. By H. R. Schoolcraft.

III. *Official reports*, embracing among others a report of Dr. Houghton on the copper of lake Superior; dated Fredonia, N. Y., Nov. 14, 1831.

Summary narrative of an exploratory expedition to the sources of the Mississippi river in 1820, resumed and completed by the discovery of its origin in Itasca lake in 1832. With appendices comprising the original report of the copper mines of lake Superior, and observations on the geology of the lake basins and the summit of the Mississippi; together with all the official reports and scientific papers of both expeditions. By Henry R. Schoolcraft. Philadelphia. Lippencott, Grambo & Co., 1855.

Besides the narrative, the following scientific papers are included in the appendix :

I. *Of the expedition of* 1820.

Results of observations for latitudes and longitudes during the expedition of 1820. By David B. Douglass, captain of engineers, U. S. A.

Report on the copper mines of lake Superior. By H. R. Schoolcraft.

Observations on the mineralogy and geology of the country embracing the sources of the Mississippi river and the great lake basins. By H. R. Schoolcraft.

Report on the value and extent of the mineral lands of lake Superior, in reply to a resolution of the U. S. Congress. By H. R. Schoolcraft.

Rapid glances at the geology of western New York beyond the Rome summit, in 1820. By H. R. Schoolcraft.

A memoir on the geological position of a fossil tree in the secondary rocks of Illinois. Albany, N. Y. E. & E. Hosford, pp. 18. 1822. By H. R. Schoolcraft.

List of plants collected by Capt. D. B. Douglass at the sources of the Mississippi river. *Am. Jour. Sci. and Arts*, vol. 4, p. 56. By John Torrey, M. D.

A letter embracing notices of the zoology of the Northwest. Addressed to Dr. Mitchell on the return of the expedition. By H. R. Schoolcraft.

Species of bivalves, collected by Mr. Schoolcraft and Captain

Douglass in the Northwest, published in the 6th volume of the Am. Jour. Sci. pp. 120—259. By D. H. Barnes.

Fresh water shells, collected by Mr. Schoolcraft, in the valleys of the Fox and Wisconsin rivers. Am. Phil. Trans., vol 5. By Mr. Isaac Lea.

Summary remarks respecting the zoological species noticed in the expedition. By Dr. Samuel L. Mitchell.

Mus bursarius. Medical Repository, vol. 21, p. 248. By Dr. Samuel L. Mitchell.

Sciurus tre-decem-striatus. Med. Repos., vol. 21. By Dr. Samuel L. Mitchell.

Proteus of the Lakes. Am. Jour. Sci., vol. 4. By Dr. Samuel L. Mitchell.

Memoranda of climatic phenomena, and the distribution of solar heat in 1820. By H. R. Schoolcraft.

II. *Of the expedition of* 1832.

Limits and range of the *Cervus sylvestris* in the northwestern parts of the United States. Northwest Journal. By H. R. Schoolcraft.

Description of the *Fringilia vespertina* discovered by Mr. Schoolcraft in the Northwest. Annals of the New York Lyceum of Natural History. By William Cooper.

List of shells collected by Mr. Schoolcraft during his expedition to the sources of the Mississippi river in 1832. By William Cooper.

List of species and localities of plants collected during the exploring expeditions of Mr. Schoolcraft in 1831 and 1832. By Douglass Houghton, M. D., surgeon to the expeditions.

A report on the existence of deposits of copper in the trap rocks of Upper Michigan. By Douglass Houghton.

Remarks on the occurrence of native silver and the ores of silver in the stratification of the basins of lakes Huron and Superior. By H. R. Schoolcraft.

A general summary of localities of minerals observed in the Northwest. By Henry R. Schoolcraft.

Geological outlines of the valley of Takwymenon, in the basin of lake Superior. By H. R. Schoolcraft.

Suggestions respecting the geological epoch of the deposit of the red sandstones of the St. Mary's falls of Michigan. By H. R. Schoolcraft.

Table of geographical positions observed in 1836. By J. N. Nicollet.

Report of a geological reconnoissance, made in 1835 from the seat of government by the way of Green bay and the Wisconsin territory to the Coteau de Prairie, an elevated ridge dividing the Missouri from the St. Peter's river. By G. W. Featherstonhaugh, U. S. geologist. Dated April 22, 1836. Printed by order of the senate. Doc. 333, pp. 168.

Notes on the Wisconsin territory, particularly with reference to the Iowa district or Black Hawk purchase, with a map. By Lieut. Albert Lea, U. S. dragoons, 1836, 16mo. 53 pages, close print.

Report intended to illustrate a map of the hydrographical basin of the Upper Mississippi river. By J. N. Nicollet in employ under the bureau of the corps of topographical engineers, and under instructions dated April 7, 1838. pp. 170, 26th Congress, 2nd session, senate, [237]. Printed Feb. 16, 1841, 500 copies ordered. Also 28th Congress, 2nd sess., House of reps. [52], Jan. 11, 1845, 1500 copies ordered.

This valuable document on the Upper Mississippi consists of:—

Part I. Physical geography of the region embraced within the map, with incidental notes on its geology, mineralogy and botany.

Part II. Comprises: determination of altitude by barometer; determination of time; determination of latitude; determination of longitude; a table showing results of observations.

[A sketch of the early history of St. Louis was prepared by Mr. Nicollet to accompany his report, but as he died without assigning it a place it is inserted after Part I.]

Appendix "A" is a table of geographical positions giving latitudes, longitudes and altitudes above the gulf of Mexico.

Appendix "B" is a catalogue of plants collected by Mr. Charles Geyer, under the direction of Mr. J. N. Nicollet during his exploration of the region between the Mississippi and Missouri rivers. By Prof. John Torrey, M. D.

Appendix "C" is a list of fossils belonging to the several formations alluded to in the report, arranged according to localities.

A Canoe Voyage up the Minnay Sotor, with an account of the lead and copper deposits of Wisconsin, of the gold region of the Cherokee country, and sketches of popular manners, &c., &c., &c. By G. W. Featherstonhaugh, F. R. S., F. G. S. The preface is dated Dec. 1846. 8vo. Vol. I has pp. 416. Vol. II has pp. 351.

Report of a geological survey of Wisconsin, Iowa and Minnesota, and incidentally of a portion of Nebraska territory. Made under instructions from the U. S. treasury department, by David Dale Owen, U. S. geologist, during the years 1847, 1848, 1849 and 1850. 4to, pp. 638, 72 wood cuts, 27 steel plates, 18 colored maps, stone and copper. Philadelphia, Lippencott, Grambo & Co., 1852.

This volume, embracing a field extending from St. Louis to the British line, and from the west shore of Lake Michigan to the Missouri river, is by far the most valuable contribution to the natural history of the Northwest that had at that time appeared. It throws the first real light, derived from the systematized science of modern times, on the geology and the present fauna and flora of Minnesota. The works of major Long and of Mr. Schoolcraft, mainly narrative or dealing with observations incidentally made on the geology and natural history of the routes they took, embrace many essential facts and able memoirs on special subjects. The report of Dr. Owen is both comprehensive and detailed. He had a numerous corps of able naturalists, and his examinations were sufficiently prolonged to enable him to gather reliable facts enough to lay down correctly the groundwork of a vast extent of scientific research. It is a fortunate thing for geology that at the head of this enterprise was a man so conscientious in his statements, and so careful in his researches. It is no rebuke to geology to say that it has suffered less from its open foes than from the rash generalizations of some of its advocates. Dr. Owen was enabled not only to prove the falsity of some of the statements of mere tourists who had passed through the state, but to establish on correct paleontological evidence the age of most of the bedded rocks of Minnesota, and to throw much light on its topography and soil. It would be expecting too much to look for a pioneer report on so vast a field that should show no errors. Some of these have already been pointed out by more recent observers who confined their examinations to certain parts of the territory on which Dr. Owen reported. Others may appear hereafter.

Dr. Owen's corps consisted of the following gentlemen:

J. G. NORWOOD, assistant geologist.

J. EVANS, B. F. SHUMARD, B. C. MACY, C. WHITTLESEY, A. LITTON, R. OWEN, heads of sub-corps.

G. WARREN, H. PRATTEN, F. B. MEEK, J. BEAL, sub-assistants.

Dr. Owen's own report, covering the first 206 pages of the volume, is divided into six chapters. He gives a brief history of the explorations of the various corps, sketches the difficulties and adventures which befell them, and names the salient points of interest in the progress and the results of the survey, in the introduction. The chapters are as follows :

Chapter I. Formations of the Upper Mississippi and its tributaries, belonging to the Silurian period.

Chapter II. Formation of Cedar, and part of Lower Iowa river, belonging to the Devonian period.

Chapter III. Carboniferous rocks of southern and western Iowa.

Chapter IV. Formations of the interior of Wisconsin and Minnesota.

Chapter V. Formations of lake Superior.

Chapter VI. Incidental observations on the Missouri river, and on the mauvaises terres (bad lands).

Dr. Norwood's report on some portions of the country adjacent to lake Superior consists of :—

Chapter I. Boundaries and topographical notices.

Chapter II. Descriptive catalogue of the rocks referred to in his report.

Chapter III. Narrative of the explorations made in 1847, between La Pointe and St. Louis river; and between Fond du Lac and the falls of St. Anthony, and on the St. Croix river.

Chapter IV. Physical structure and geology of the northwestern and western portions of the valley of lake Superior.

Col. Chas. Whittlesey's report pertains to that portion of Wisconsin bordering on the south shore of lake Superior.

Chapter I. General description and geology of the Bad river country, and of that between the Bad river and the Brule; with descriptions and detailed sections of rocks like those which in Michigan are copper-bearing; and accounts of the magnetic iron beds of the Penokie iron range, and of "Iron ridge," in Dodge county, Wisconsin.

Chapter II. Description of the country between the Wisconsin and Menomonie rivers; with a discussion of the general geology, and its relations to other parts of the Northwest.

Chapter III. Red clay and drift of Green bay and Wisconsin.

Chapter IV. Barometrical and thermometrical observations.

Chapter V. Lumbering on the waters of Green bay.

Dr. B. F. Shumard's report pertains to local and detailed observations in the valleys of the Minnesota, Mississippi and Wisconsin rivers.

Chapter I. Detailed observations on the St. Peter's and its tributaries.

Chapter II. Local sections on the Upper Mississippi.

Chapter III. Local sections on the Wisconsin and Baraboo rivers.

Chapter IV. Observations on Snake, Kettle and Rush rivers.

Dr. J. Leidy furnished for the volume a memoir on the remains of extinct *Mammalia* and *Chelonia* from Nebraska territory.

The appendix embraces :—

Article I. Description of new and imperfectly known genera and species of organic remains collected during the geological surveys of Wisconsin, Iowa and Minnesota. By D. D. Owen.

Article II. Descriptions of one new genus and twenty-two new species of *Crinoidea*, from the *Subcarboniferous limestone* of Iowa. By D. D. Owen and B. F. Shumard.

Article III. Summary of the distribution of orders, genera and species in the Northwest.

Article IV. Additional chemical examinations. By D. D. Owen.

Article V. Systematic catalogue of plants of Wisconsin and and Minnesota. By C. C. Parry.

Article VI. Table of stratigraphical and geographical distribution of genera and species in the Northwest.

The Pembina settlement. Letter from the secretary of war transmitting report of Maj. Wood relative to his expedition to Pembina settlement, and the condition of affairs on the northwestern frontier of the territory of Minnesota. Mar. 19, 1850. 8vo. pp. 55. Ex. Doc. No. 51, 31st Cong., 1st session.

Letter from the secretary of war communicating the report of an expedition to the territory of Minnesota. By brevet Capt. Pope, Feb. 5, 1850. Senate, 31st Congress, 1st Sess. Ex. Doc. No. 42, pp. 56. Comprises nine chapters and an appendix containing tables of distances.

Letter from the secretary of war transmitting report of brevet

captain J. L. Reno, on the survey, &c., of a road from Mendota to the Big Sioux river. 33rd Congress, 1st session, House of Representatives [97], pp. 12.

Reports of explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean. Made under the direction of the secretary of war in 1853–4, according to acts of Congress of May 3, 1853, May 31, 1854, and August 5, 1854. Thirteen volumes, 4to., Washington, 1856–60.

Single papers.

1. Route near the 47th and 49th parallels of north latitude, vol. I. pp. 39–55.

2. Synopsis of a report of the reconnoissance a i lroad route from Puget sound, via Smith's pass to the Mississippi river. By Fred W. Lander, C. E.; vol. II, pp. 45.

Vol. XII. Parts I and II are wholly devoted to the Northern Pacific route, viz:

Part I. Narrative and final report of exploration for a route for Pacific R. R. near the 47th and 49th parallels of north latitude, from St. Paul to Puget sound. By I. I. Stevens, governor of Washington territory, 1855, pp. 358. 41, 2 maps, 1 profile, 70 engravings.

Part II. Botanical report, pp. 7–76, 6 plates; zoological report, pp. 1–399, 76 plates.

Letter, upon the agricultural and mineral resources of the northwestern territories, on the route of the Northern Pacific R. R. By Philip Ritz, Washington, D. C.; 8vo. pp. 8, 1868.

Minnesota. Its place among the states. Being the first annual report of the commissioner of statistics, J. A. Wheelock, for the year ending Jan. 1st, 1860, 8vo. pp. 171.

Minnesota. Its progress and capabilities. Being the second annual report of the commissioner of statistics for the years 1860 and 1861. By J. A. Wheelock. 8vo. pp. 126.

Notes on the geology of some portions of Minnesota from St. Paul to the western part of the state. By James Hall, 1866, 4to. pp. 12. Read June 15, 1866, before the Phil. Soc. of Philadelphia.

Survey of the upper Mississippi river. Letter from the secretary of war in answer to the resolution of the House * * * with general Warren's report of the surveys of the upper Mississippi river and its tributaries, 8vo., pp. 116, Sen. Doc. 39th Cong., 2d Sess. Feb. 15, 1867.

Report of Gen. Warren on the survey of the upper Mississippi river, for the year ending June 30, 1867, 8vo. pp. 6. [Printed in appendix "D," report of the chief of engineers; and as Ex. Doc. No. 1. House of Reps., 40th Cong., 2d Sess., Sept. 14, 1867.]

Report of Gen. Warren on the survey of the upper Mississippi river for the year ending ?. 8vo. pp. 10, 40th Cong., 2d sess. Ex. Doc. 247. April 8, 1868.

Report of Gen. Warren for the year ending June 30, 1868, on the survey of the upper Mississippi river. 8vo. pp. 86. [Printed in appendix "G," report of chief of engineers; and as Ex. Doc. 1, Part II., House of Reps., 40th Cong., 3d sess., Aug. 31, 1868.]

On certain physical features of the upper Mississippi river. By Gen. G. K. Warren. Read by Gen. Warren before the Am. Assoc. Adv. Sci., Aug., 1868, Chicago, Ill. [Printed only in the American Naturalist for November, 1868.]

Geology of southern Minnesota. A series of five papers by W. D. Hurlbut, published in the 4th volume of the Minnesota Teacher, 1871.

Geological rambles in Minnesota. Two papers published in the 4th volume of the Minnesota Teacher, 1871. By J. H. Kloos.

A Cretaceous basin in the Sauk valley, Minnesota. By J. H. Kloos. A paper published in the Am. Journal of Science and Arts, Jan. 1872, dated October, 1871. Condensed and republished in the Minnesota Teacher, vol. 5., 1872.

The first State Legislature met in 1859. Although it was burdened with the legislation incident to the organization of the various institutions of the new State, the subject of a geological survey and its evident importance to the material development of the State, received due attention. A law was passed ordering at once a reprint of portions of the geological report of Wisconsin, by professor Daniels, for the years 1854 and 1858. This republication, printed in 1860, contained Prof. Daniels' "Sketch of the Lead Region," with notes on the evidences of iron ore, which closed with a statement of the "objects of a geological and natural history survey," embracing 34 pp. It also embraced a paper, read before the American Geographical and Statistical Society on the 31st of January, 1856, by Mr. A. S. Hewitt, on the "Statistics and History of the production of iron." pp. 47. Five hundred copies ordered printed.

The second Legislature passed March 10, 1860, a concurrent resolution providing for "Commissioners" to report on the geology of the state, and to submit a plan for a thorough geological survey of the state. The commissioners appointed were Charles L. Anderson and Thomas Clark. These gentlemen submitted separate reports under the date of Jan. 25, 1861, making an octavo pamphlet of 26 pages, of which 2,000 copies were ordered printed. This pamphlet embraces a chapter on the *general geological features of Minnesota*, and one on a *plan for a geological survey*, by Mr. Anderson; also one by Mr. Clark on the *meteorology of the state*, and another on some general topographical and geographical features of the northeastern portion of the state.

The report of the state geologist, Aug. H. Hanchett, M. D., is a pamphlet of 82 pages, 8vo., and is dated New York city, Nov. 13, 1864. It was made in pursuance of executive instructions bearing date July 12, 1864. It contains a short report of ten pages, by Dr. Hanchett, and a valuable report by Mr. Clark on (1) *The physical geography* of the district embraced in that portion of the state bordering on lake Superior. (2) A discussion of the *meteorology of the district.* (3) *A list of the leading plants and trees* of the district. 500 copies printed.

The first report of H. H. Eames, as state geologist, was made in pursuance of an act of the seventh Legislature, and printed in 1866. Two editions of 3,000 copies each were ordered. It is a pamphlet of 23 pages, and pertains specially to "*The metalliferous region bordering on lake Superior.*" It gives the details of personal explorations and the results of chemical assays of ores for the precious metals.

Report of explorations in the mineral regions of Minnesota, during the years 1848, 1859 and 1864; by Col. Chas. Whittlesey. Printed by order of the legislature in 1866, 8vo. pp. 52, close type, with wood-cut illustrations. 3,000 copies ordered.

This, by far the most valuable state document pertaining to the geology and natural history of the state that has yet appeared, embraces short chapters as follows: *General geology; phenomena of the drift period; general elevations in Minnesota; fluctuations in the level of the lakes*; *climate.*

Notes on the valley of the Baragas river.

"	"	Kawimbash river.
"	"	Two Islands river.
"	"	Manedowish river.
"	"	Baptism river.
"	"	Palisade river.
"	"	Beaver river.
"	"	Low Bush river.
"	"	Encampment river.
"	"	French river.
"	"	Knife river.
"	"	Sucker river.
"	"	Henry Schmidt's river.
"	"	Hollow Rock river.
"	"	St. Louis river.
"	"	Rainy Lake river.

Notes on the shores of the Esquamega, Vermilion and Crane lakes and on the cost of mining copper.

Geological reconnoissance of the northern, middle and other counties of Minnesota. By Henry H. Eames, state geologist, printed in 1866, 8vo., 58 pp. This pamphlet comprises the second, and last, report of Mr. Eames. It embraces:

A brief outline of the different formations or systems of rocks that form the crust of the earth; remarks on the igneous, the coal-bearing, and the sandstone and limestone rocks of the state; also on peat; on mineral and fissure veins; on agricultural chemistry; on a geological reconnoissance "in detail" of the counties of St. Louis, Lake, Itasca, Cass, Todd, Otter Tail, Douglas, Stearns, Morrison, Benton, Sherburne, Redwood, Cottonwood, Ramsey and Washington; together with results of assays and thermometrical and barometrical observations in the months of June, July and August.

Copper-bearing veins having been discovered in the valley of the Kettle river, and at Taylor's Falls, in the valley of the St. Croix river, the Legislature passed, Mar. 2, 1865, an act to aid in their investigation. The report of Mr. N. C. D. Taylor, the following year, consists of only two pages, incorporating Mr. James Hall's estimate of the copper prospects of that district. 500 copies printed.

Indications of brine having been discovered at Belle Plaine, in

Scott county, the Legislature passed, 28th day of February, 1870, an act appropriating land in aid of a boring for the purpose of developing the salt, should any exist. In 1871 another similar appropriation was made by the legislature, conditional on a favorable report by a competent geologist, to be appointed by the governor. Prof. A. Winchell, of Ann Arbor, Mich., having been so appointed, made the required examination; and his report, dated June 17, 1871, was printed by order of the Senate. It is an 8vo. pamphlet of 16 pages. Notwithstanding the unfavorable opinion of the geologist, the Legislature made the further appropriation, Feb. 29, 1872, of six other sections of "state salt lands," for the further sinking of the well, making eighteen sections or eleven thousand three hundred and twenty acres of land in all. No brine in workable quantities was obtained.

The same legislature passed, March 1st, 1872, the present comprehensive law placing the geological and natural history survey under the direction of the board of regents of the state university. This law reads as follows:

GENERAL LAWS OF MINNESOTA, 1872, CHAPTER XXX.

An Act to provide for a geological and natural history survey of the state and to entrust the same to the University of Minnesota.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. It shall be the duty of the board of regents of the University of Minnesota to cause to be begun as soon as may be practicable, and to carry on a thorough geological and natural history survey of the state.

SEC. 2. The geological survey shall be carried on with a view to a complete account of the mineral kingdom as represented in the state, including the number, order, dip, and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines and mineral waters, marls, cements, building stones and other useful materials, the value of said substances for economical purposes and their accessibility; also an accurate chemical analysis of the various rocks, soils, ores, clays, peats, marls and other mineral substances, of which complete and exact records shall be made.

SEC. 3. The natural history survey shall include, first an examination of the vegetable productions of the state, embracing all

trees, shrubs, herbs and grasses native or naturalized in the state; second, a complete and scientific account of the animal kingdom as properly represented in the state, including all mammalia, fishes, reptiles, birds and insects.

SEC. 4. The said surveys and examinations shall be made in the manner and order following: first, the geological survey proper, together with the necessary and implied mineralogical investigations, all of which shall be undertaken as soon as may be practicable, and be carried forward with such expedition as may be consistent with economy and thoroughness; second, the botanical examinations; third, the zoological investigations; provided, however, that whenever the said board of regents may find it most economical to prosecute different portions of the surveys in conjunction, or that the public interest demands it, they may, in their discretion, depart from the above prescribed order. And in the employment of assistants in the said surveys, the board of regents shall at all times give the preference to the students and graduates of the University of Minnesota, provided the same be well qualified for the duties.

SEC. 5. The said board of regents shall also cause to be collected and tabulated such meteorological statistics as may be needed to account for the variety of climate in the various parts of the state; also to cause to be ascertained [by] barometrical observations or other appropriate means the relative elevations and depressions of the different parts of the state; and also on or before the completion of the said surveys, to cause to be compiled from such actual surveys and measurements as may be necessary, an accurate map of the state, which map when approved by the governor shall be the official map of the state.

SEC. 6. It shall be the duty of said board of regents to cause proper specimens, skillfully prepared, secured and labelled, of all rocks, soils, ores, coals, fossils, cements, building stones, plants, woods, skins and skeletons of animals, birds, insects and fishes, and other mineral, vegetable and animal substances and organisms discovered or examined in the course of said surveys, to be preserved for public inspection free of cost, in the University of Minnesota, in rooms convenient of access and properly warmed, lighted, ventilated and furnished, and in charge of a proper scientific curator; and they shall also, whenever the same may be practicable, cause

duplicates in reasonable numbers and quantities of the above named specimens, to be collected and preserved for the purpose of exchanges with other state universities and scientific institutions, of which latter the Smithsonian Institution at Washington shall have the preference.

SEC. 7. The said board of regents shall cause a geological map of the state to be made, as soon as may be practicable, upon which, by colors and other appropriate means and devices, the various geological formations shall be represented.

SEC. 8. It shall be the duty of the said board of regents, through their president, to make, on or before the second Tuesday in December of each and every year, a report showing the progress of said surveys, accompanied by such maps, drawings and specifiactions as may be necessary and proper to exemplify the same to the governor, who shall lay the same before the legislature; and the said board of regents upon the completion of any separate portion of the said surveys, shall cause to be prepared a memoir or final report, which shall embody in a convenient manner all useful and important information accumulated in the course of the investigation of the particular department or portion, which report or memoir shall likewise be communicated through the governor to the legislature.

SEC. 9. To carry out the provisions of this act the sum of one thousand dollars per annum is hereby appropriated, to be drawn and expended by the [said] board of regents of the University of Minnesota.

SEC. 10. This act shall take effect and be in force from and after its approval.

Approved March 1, 1872.

II.

GENERAL PRINCIPLES.

The science of geology is based on those general principles which, resulting from the accumulated observations of its advocates during the last half century, have become to the geologist himself the merest alphabet to which he seldom recurs in the prosecution of his more advanced investigations. The following brief statement of those principles is here given for the benefit of those persons who are not specially acquainted with the science, but yet are fascinated, perhaps, by its wonderful progress, and its success in utilizing its discoveries to the general good, and wish to comprehend at a glance the sub-structure on which it is built. It is not an occult science. Its data are open to the investigation of the commonest observer. It is founded on such simple things as the running of brooks, the blowing of winds, the rippling of waves, the shining of the sun, the cooling of heated matter, the growth of vegetation and the death of animals that live on land and in the sea. These everyday operations have given to the earth its external aspects, and have left their history in the rocks. The constancy of the present laws of nature through the lapse of the geological ages, is a pre-requisite to the existence of the science. Time, as the word is commonly understood, must be immensely lengthened out. These two postulates granted—*that time is long*, and *that the physical laws of the universe have been constant throughout time*—and nothing more is needed for the foundation of the science. The geologist, with these postulates, and by the aid of a knowledge of the physical laws of nature derived from a comprehensive examination of the earth in the light of all the sciences, may read in the rocks the grand changes the earth has undergone since "the beginning." The failure to comprehend the science of geology is very often attributable to a restricted acquaintance with the principles of other sciences which it involves; for however simple the first process in which it begins, those processes are,

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en duly amplified, very often the starting points of other sci-es which first grew up, expanded and usurped the whole field of ntific thought. It is a simple thing to observe the growth of lant from the seed—it is another to know the relations of that ant to others by which it may be surrounded, and by botanical ssification to define its nature and structure. It is an easy thing see the effect of the sun's rays on the vegetation of the earth, d to comprehend the cause for the change of the seasons, as well to note the alternations of day and night, but the versed astron-ner only can realize the full force of the great laws involved in ese changes, and indicate their effect on the earth when acting rough the lapse of ages. It is an easy thing to note the freezing p of the streams, and their bounding violence on being released the spring; to see the destruction of forests by tempests and by res; to observe the blowing of sands and the dashing of waves; ut, although these things are very simple, the science of meteor-logy is too abstruse to be even fairly appreciated by the common nind. The rusting of iron, the decaying of wood, the cementation f gravel by percolating water, the demolition of rocky outcrops nd their conversion into soil by the solvent action of the moisture f the air and of overflowing streams, are things of common and asy observation, but the science of chemistry, in the light of which hey alone can be adequately understood, is the outgrowth of the aws of occult affinities between the particles of matter, the full ower of which it is impossible to estimate, and much more to ex-ress. Thus all the sciences, and notably that of zoology, have ielded up to the geologist their keys to the *arcana* of nature, and ave assisted in interpreting the otherwise unintelligible records hich lie in the rocks of the earth. The geologist must not be re-tricted to the mere inspection of the rocks, for he has to question he botanist, the chemist, the zoologist, the astronomer, and the eneral physicist. These are in a broad sense his aids. By his eneralizations the society of the sciences is made evident, and ome of their varied bearings one upon the other are adjusted, and xpressed in their full significance. In return the science of geol-gy reflects light on the other sciences. It gives greater value to he labors of the mineralogist, guides the miner in his explorations, pens fields for investigation to the chemist, shows the botanist nd the zoologist thousands of unnamed and unclassified species,

propounds to the astronomer the *glacial epoch* for explanation, and explains to the agriculturist the true basis of the difference in soils.

The rocks which are classed, in general, as *Granitic and Metamorphic* are those which appeared first above the waters of the universal ocean, or have since been upheaved by internal forces from the heated mass within the crust. In the former case they have been dry land since they first appeared above the ocean, and have supplied largely the materials of the later, overlying, sedimentary formations. In the latter case they have been protruded upward through the sedimentary rocks, tilting them in various directions and so fracturing their bedding as to disclose their contents to the geologist. Round the bases of these early granitic areas the currents of the ocean, driven by the rising and falling of the tides, by the rotary motion of the earth, and by the unequal distribution of the heat of the sun, flowed with an unceasing activity, and the tumultuous waters beat with a violence that probably is never witnessed in modern days. They were thus gradually torn down, and their *debris* was spread over the uneven ocean bed in horizontal layers according to the direction and force of the currents. In that manner the primordial, or *Potsdam*, sandstone was formed. It hence everywhere lies at the base of the evidently sedimentary rocks. *It was deposited in the bed of the ocean.* If it now appears as dry land, it is because the ocean's bed has risen above the water level. The history which may be read from it is that of the ocean's bed. It tells of deep waters and shoal waters, of muddy bottoms and stony bottoms, of warm, drying sunshine and gentle winds, of violent currents and stormy seas, of impure waters heated by frequent ejections of sulphurous gases from below the thin crust, and of chemical reactions that to-day are the familiar steps of the laboratory. It reveals the earliest of created beings. They lived in the ocean. Their remains are dug out of the hardened sediment by the geologist, and he calls them *fossils.*

The changes that continued to go on in the conditions of the earth, owing to the cooling and the shrinking of the interior, effected various changes in the relative prevalence and positions of the land and water. Additional dry land appeared, thus bringing from the bed of the ocean a part of the freshly formed *Potsdam sandstone.* A period of repose sufficed for the deposit of the calcareous material of the *Lower Magnesian*, which next overlies the

Potsdam. This, however, was not spread over the earlier sandstone, except where the latter still extended below the ocean. It was accompanied with new and more abundant forms of animal life, so that it may be certainly distinguished from the foregoing and from the succeeding formations. The conditions of the oceanic waters were such that chemical reactions resulted in the precipitation of the carbonates of lime and magnesia. Silica, also, seems to have been in solution, and to have shared in the incessant changes in the surrounding affinities. These three substances, with some iron and traces of alumina and manganese, make up the mass of the *Lower Magnesian limestone.* The prevalence of silica in the form of sand gives it also the name of *Calciferous sandrock.* The chert, in its lower portions, is also largely composed of siliceous material.

To the *Lower Magnesian* succeeds the *St. Peter sandstone.* That in turn is followed in ascending order by the *Trenton* shales and limestones. Thus, through the whole thickness of the stratified rocks of the earth, each formation marks an epoch in the history of the ocean's bed. The dry land constantly increased in area, gradually bringing to the surface the sediments of the latest preceding epoch. Hence the areas of the various formations are arranged over the face of the country in broad belts in consecutive order, revealing the chronological system as well as the territorial accessions with which the continent grew.

The rocks thus deposited in the bottom of the ocean, and subsequently raised to the level of dry land, are called stratified or aqueous, in distinction from the earliest, or igneous, which show no arrangement into beds. The lowest sedimentary rocks are locally so changed by contact with escaping gases and molten material as to essentially alter their usual character. The limestones have been converted to saccharoidal marbles, the sandstones to quartzytes, the clays and shales to slates, while many of the earliest are also entirely changed by chemical transformations among their elements, resulting from the same grand agencies, to schists and even gneiss, mica and hornblende slate, that can hardly be distinguished from some of the igneous rocks themselves. The geologists of Canada even report granite and syenite, pertaining to the Laurentian, as metamorphic sedimentary rocks. (See Geology of Canada, 1863, p. 23)

It is evident that when the true succession of the rocks of the

earth has once been made out by the study of their permanent characters, the geologist may enter any country however remote or unknown and enter fearlessly on the work of deciphering the age of its rocks, depending solely on the universality of the grand principles of his science.

A complete geological history of the past can be read from the rocks of the earth only by the study of causes and effects operating in the present. In order to that a perfect acquaintance with the various departments of natural science becomes essential. The laws of physics, chemistry and astronomy have with their multiform ramifications played as important parts in the early geological ages as they now play in the transactions of every day. The natural forces concerned in vegetable growth, distribution and decay, are involved in the deposition and preservation of the coal rocks in their proper horizon. Hence botany with its allied subject, meteorology, is embraced in a perfect knowledge of geology. The identification of the rocks of the great *Coal Period*, as distinguished from others containing coal, is based on a botanical law, a distinction in plants. As to zoology, that subordinate department derives much of its significance and value from the uses it subserves to geology. Its nomenclature, and its principles have been wonderfully modified and extended by the discovery and proper classification of the animal forms embraced in the strata of the earth's crust, while the science of zoology furnishes to the geologist the only reliable key to the establishment of the age of any of the stratified rocks of the earth. All characters, except those known as paleontological, fail of permanence, and cannot be depended on at distant points. A geological survey cannot be conducted, much less completed, without a full examination and delineation of the animals and plants that are preserved in the rocks surveyed. The dead past far outnumbers the living present. It is with the greatest propriety that botanical and zoological departments are usually attached to the geological surveys undertaken by the various states of the union, intended to embrace also the enumeration of living species.

The subjoined chart of geological nomenclature is intended to convey an idea of the relation of Minnesota to the great geological series of the earth, and to express the probable equivalency of some of the names which the formations have received in different states and in Europe.

III.

THE SURFACE CONTOUR OF THE STATE.

The intimate relation subsisting between the geology and the topography of the state is more evident than in some of the other states of the union. The causes which determine the location of the great continental water-shed are those which determined the existence of the Laurentian and lake Superior ranges of igneous and metamorphic rocks. The area of these rocks in Minnesota, as well as in Wisconsin and Michigan, includes some of the sources of the great river systems of the Northwest and of the continent. From this area, since pre-Silurian times, streams have run in all directions toward the ocean. Within this area, in the state of Minnesota, are the headwaters of the St. Lawrence system of drainage, which enters the Atlantic ocean toward the east; those of the Mississippi which enters the gulf of Mexico toward the south, and those of the Red river of the North, which, taking an opposite course, finds the ocean level toward the north, through Hudson's bay, in British America. This watershed consists not in the form of a definite and abrupt ridge. The oldest rocks are, on the contrary, spread out over a very extensive region of flat and often prairie country. Occasional knobs of these rocks protrude through the drift, or they show extensive tracts of denuded surface, rising but few feet above the surrounding level.

While in general these rocks form the principal watershed, in some parts of the state the later sedimentary rocks rise much higher and give origin to numerous streams which reach the main valleys at considerable distance from the granite areas. Such an elevated area of sedimentary rocks occurs in southern Minnesota, forming there the summit of a second water-shed. Freeborn, Faribault, Martin and Cottonwood counties are probably the most elevated in the state, the altitude there reaching nearly 1,600 feet above the ocean. How much of this extraordinary elevation is due to a moraine-like accumulation of drift, it is impossible to say,

but probably the average thickness of that deposit would not fall short of one hundred feet. Streams from this area enter Iowa toward the south, some also running northward and joining the Minnesota river. The course of the surface drainage is in this case dependent very little on the character of the underlying rock. But where the drift is lighter, the direction of subordinate streams is often determined by the bearing of the sedimentary rocks. A stream is most likely to be located in the depression caused by the erosion or other destruction of the outcropping edge of a soft or friable rock, the more persistent formation adjoining it, above and below, forming the divides between it and other streams. Other causes, however, principally those superinduced by undulations in the strata over long distances, so as to cause them to leave the direction of the principal or tributary valleys, and the variations of level brought about by the unequal deposition of the drift during the prevalence of the ice of the glacial epoch, have very generally masked the effect of unequal erosion of the strata on the direction of surface drainage. One remarkable instance of the effect of geological causes in determining the location of valleys, and hence of drainage streams, through variations in the hardness of the underlying rock, may be mentioned. The Mississippi river, from a short distance below the mouth of the St. Croix to the southern boundary line of the state, and to the mouth of the Wisconsin river which joins it at Prairie du Chien from the east, flows through a tract of country in which the drift forces acted with far less violence than in other tracts further to the east or west, or even further to the south. Whatever may be the cause of the comparative exemption of this district from the prevalence of the drift in that latitude in other parts of the United States, it is a fact so observable that Mr. J. D. Whitney, some years ago, denominated it a "driftless region," where it enters the state of Iowa. Hence it is here, if anywhere, that the character of the underlying rock would influence the direction of drainage. Throughout this distance the bluffs of the Mississippi are specially elevated and rocky. The river has not infrequently cut into the formations, with which it comes in contact, a perpendicular depth of over six hundred feet, excavating a channel often of four or five, and sometimes of nearly ten miles in width. Sometimes old channels that have been abandoned lie along one side, or both, and are filled

with water only during the freshet season. Throughout this distance it follows exactly the strike of the Lower Silurian rocks. The *St. Peter sandstone*, on which it enters at St. Anthony's falls, is underlain by a very enduring rock known as the *Lower Magnesian limestone*. That, in order, is also underlain by the more erosible sandstones of the St. Croix valley. Hence we have an enduring limestone rock intercalated between two easily destructible sandstones. Yet it is a remarkable fact that this limestone, the strike of which would ordinarily form, under the operation of natural causes, a ridge or divide turning the surface waters in opposite directions into the valleys of the sandstone areas, forms the summits of the river bluffs nearly the whole distance. The river has not only cut its channel through the first sandstone, a thickness of over one hundred feet, and the *Lower Magnesian limestone*, a thickness of about three hundred feet, but also into the lower sandstone to the depth of two or three hundred feet, on which it is now running. At the present time the river lies in the strike of the more enduring limestone, the overlying sandstone having retreated from the immediate river banks. Its agency in locating the river is only manifest by the existence to the present day, of isolated outliers of it, in the form of the well known "Trenton mounds," on the eastern side of the river, its present line of outcrop running some miles further west. While the river has been slowly wearing its way into the *Lower Magnesian limestone*, and through it into the *St. Croix sandstone*, on the line where the overlying *St. Peter sandstone* predetermined it, the *St. Peter* itself has almost entirely disappeared from the river, and been lost under the attacks of the elements, its substance having been spread over the high prairies, or on the low bottom lands, as the principal ingredient of the rich loams which characterize that portion of Minnesota. Hence we also have the singular phenomenon of a slight descent in the surface of the country westward from the tops of the bluffs of the Mississippi, in southern Minnesota, while the streams tributary to it actually reach it by flowing to the east. This can be explained only on the supposition that the *St. Peter sandstone* formerly had its outcrop about where the Mississippi now runs, forming then there, as it forms now along its line of junction with the *Lower Magnesian limestone*, a marked depression in the general surface, but that in the lapse of time its

line of outcrop, and necessarily that of all overlying rocks, was driven, by the operation of destructive agencies, further to the west, leaving the next lower formation to round out the bluffs along the river. The tributary streams, having once entered the Mississippi from the west, would keep their beds also eroded down to a level with that river, and would continue to enter that stream by passing in like manner between high and rocky banks, which would attain their greatest hight just at their union with the bluffs of the Mississippi. At Prairie du Chien the direction of the strike of the *St. Peter sandstone*, and of all the Silurian rocks changes, and passes away from the Mississippi valley toward the east. But the Wisconsin river bears the same relation to the *St. Peter sandstone*, running along its ancient line of bearing, its main outcropping edge being driven away from the immediate valley toward the south, while outliers on the northern side attest its former prevalence intact over the whole valley.

Enough has been said to show the importance of a knowledge of elevations above a common level at all ascertained points throughout the state. Efforts have been made to obtain the hypsometrical data of the state complete up to the present time, so far as indicated by railroad or other surveys. The following list of elevations is the result. To this list additions will be made from time to time. The figures show the altitudes of the points named above lake Superior, and above the ocean. When not otherwise mentioned, the points given are on the grade of the road.

On the line of the Lake Superior & Mississippi R. R.

FURNISHED BY A. J. HILL.

Miles from Duluth.		Feet above lake Superior.	Feet above the ocean.
0	Surface of lake Superior at Duluth in 1870.......	0	602
0	Duluth..	6	608
21	Thomson. Dalles of the St. Louis river..........	430	1032
33	Highest point on entire line, both of grade and natural surface.................................	569	1171
45	Moose Lake depot..............................	462	1064
60	Kettle River depot. (Ground a little to the north and south is 15 to 20 feet higher).............	428	1030
78	Hinckley, at Grindstone river	429	1031
	Lowest place between Hinckley and next summit, grade..	408	1010
80	Summit, grade..................................	418	1020
86	Summit, (20 feet higher than at ½ mile to the N. or S.), grade..	388	990
90	Pine City, at Snake river.........................	347	949
	Two and a half miles south of Snake river, at summit, grade..	381	983
101	Rush City, at creek...............................	314	916
	Descending gradually from Rush City to Goose creek		
	Goose creek, grade..............................	289	891
	Between Goose creek and N. Branch.............	318	920
113	N. Branch depot..................................	292	894
	Between N. Branch and Wyoming...............	309	911
125	Wyoming, at the river, grade.....................	291	893
125	Wyoming depot..................................	294	896
129	Forest Lake depot...............................	307	909
132	Summit between Forest Lake and Rice creek.....	352	954
133½	Rice creek, grade................................	319	921
	Country generally level for five miles south of Rice creek.		
137½	Centerville depot.................................	329	931
142½	White Bear, junction to Stillwater..............	332	934
145¼	Summit between White Bear lake and St. Paul (8 feet cut), grade..................................	362	964
151	Between Phalen's lake and St. Paul..............	273	875
154	Lowest known water in Miss. R. at St. Paul.......... Extreme range 19 feet.	81	683
154	Highest known water in Miss. R. at St. Paul..............	100	702

On the line of the Northern Pacific R. R.

FURNISHED BY W. MILNOR ROBERTS, CHIEF ENGINEER.

Miles from Duluth.		Above lake Superior.	Above the ocean.
0	Duluth (level of L. Superior) about	0	602
24	Junction (natural ground)	479	1081
24.2	Junction (grade)	480	1082
27	Otter creek (bed of creek)	526	1128
34	(natural ground)	733	1335
34.1	Norman (grade)	722	1324
41.7	Kettle river (bed of the river)	685	1287
44.7	(natural ground)	729	1331
46	Island lake (grade)	705	1307
51.7	Tamarack river (bed of the river)	685	1287
51.9	(natural ground)	709	1311
55.2	(natural ground)	678	1280
58.1	Sicottes (grade)	665	1267
62.2	Hay river (bed of the river)	622	1224
62.8	(natural ground)	638	1240
65.4	Sandy river (bed of the river)	613	1215
72.3	(natural ground)	612	1214
73.8	(natural ground)	660	1262
76	Kimberly (grade)	631	1233
76.5	Rice river (bed of the river)	603	1205
80.8	(natural ground)	648	1250
83.5	Sisabagama creek (bed of creek)	600	1202
85.3	(natural surface)	635	1237
87.1	Aitkin (grade)	602	1204
87.7	Mud river (bed of the river)	586	1188
90.2	(natural ground)	618	1220
91.8	Cedar river (bed of the river)	593	1195
97.5	(natural surface)	699	1301
98.2	Deerwood (grade)	666	1268
103.6	(natural surface)	697	1299
115	Brainerd (grade)	604	1206
115.5	Mississippi river (bed of river)	538	1140
	Banks of the Mississippi river (grade)	604	1206
120.6	Frenchman's (grade)	599	1201
120.9	(natural ground)	606	1208
122.5	Gull river (bed of the river)	561	1163
124.7	(natural ground)	604	1206
127.6	Pillager creek (bed of creek)	566	1168
128.2	Pillager (grade)	580	1182
135.5	(natural ground)	622	1224
136.5	Crow Wing river (bed of the river)	597	1199
137.1	Motley (grade)	620	1222
141.5	(natural ground)	650	1252
143.3	Hayden's branch (bed of creek)	624	1226
150.9	(natural ground)	742	1344
151.3	Aldrich (grade)	726	1328
151.5	Partridge river (bed of river)	704	1306
155.3	(natural ground)	747	1349
156.5	Wing river (bed of river)	712	1314
158.2	(natural ground)	757	1359

On the line of the Northern Pacific R. R.—continued.

Miles from Duluth.		Above lake Superior.	Above the ocean.
161.3	Union creek (bed of creek)........	720	1322
161.9	Wadena (grade).......	749	1351
164.1	(natural ground).................	754	1356
166.4	Leaf river (bed of river)....	707	1309
174.8	New York Mills (grade)................	809	1411
177.2	(natural ground)..................	831	1433
183.4	Otter Tail river (bed of river).........	718	1320
185.5	Perham (grade).....	766	1368
190.7	(natural ground)................	779	1381
192.6	Otter Tail river (bed of the river)	735	1337
195.4	Hobart (grade).................................	784	1386
196.1	(natural ground)..................	802	1404
196.2	Otter Tail river (bed of the river)	753	1355
201.4	(natural ground)........	820	1422
205.8	Pelican river (bed of the river)..................	737	1339
206.6	Detroit (grade).................................	762	1364
210.7	(natural ground).......	806	1408
210.9	Oak Lake (grade)...	767	1369
213.6	Audubon (grade)...............	708	1310
214.7	(natural ground).................	667	1269
217	(natural ground),.........	748	1350
219.2	Lake Park (grade)............	733	1335
224.2	Hay creek (bed of crrek)...............	600	1202
226.6	Hay creek (bed of creek)........................	567	1169
227.4	Buffalo river (bed of river).	550	1152
230.1	Buffalo river (bed of river)..................... ..	532	1134
230.4	Hawley (grade)..................................	550	1152
231.4	(natural ground).................	595	1197
234.9	Muskoda (grade)..............	483	1085
238.3	Buffalo river (bed of river)......................	338	940
242	Red river flats (natural ground)	378	980
243.2	Glyndon (grade).	323	925
252	Moorhead (grade).......	304	906
252.2	Red river (bed of river)..........	257	859
	Red river banks (natural ground)......	302	904

On the line of the St. Paul & Sioux City and Sioux City & St. Paul R. R.'s.

FURNISHED BY HON. E. F. DRAKE.

Miles from St. Paul.		Above lake Superior	Above the ocean.
47	Belle Plaine	123	725
52	Blakely	126	728
58	East Henderson	132	734
63	Le Sueur	151	753
69	Ottawa	188	790
77	Kasota	198	800
86	Mankato	189	791
90	South Bend	206	808
100	Lake Crystal	392	994
110	Madelia	419	1021
121	St. James	471	1073
130	Butterfield	582	1184
137	Mountain Lake	698	1300
143	Bingham Lake	818	1420
148	Windom	751	1353
154	Wilder	846	1448
160	Heron Lake	815	1417
170	Hersey	883	1485
178	Worthington	980	1582
188	Bigelow	1029	1631
196	Sibley	907	1509
245	Le Mars	619	1221

St. Paul & Pacific R. R.—Main line.

FROM THE RECORDS IN THE OFFICE OF THE CHIEF ENGINEER, C. A. F. MORRIS. BY N. H. W.

Miles from St. Paul.		Above lake Superior	Above the ocean.
0	Low water in Mississippi river at St. Paul	81	683
0	St. Paul depot	102	704
0	Base of the capitol, St. Paul	190	792
0	Bluffs back of the capitol—		
	Head of Robert street	308	911
	Summit avenue bluff	318	920
5	Summit between St. Paul and St. Anthony (3 feet cut)	328	930
9.5	Junction at St. Anthony	240	842

S Paul & Pacific R R —Main line—continued.

Miles from St. Paul.		Above lake Superior	Above the ocean.
9.5	Mississippi R. (low water) at Nicollet island, St. Anthony	198	800
10.5	Minneapolis station	232	834
	Mississippi R. (low water) half mile below St. Anthony falls	118	720
17	Self's lake (water)	253	855
24	Wayzata station	334	936
25	Lake Minnetonka (water)	326	928
28	Long Lake station	352	954
40	Crow River crossing (track)	326	928
40	Delano	326	928
48½	Waverly station	397	999
51½	Twelve Mile creek (track)	398	1000
54	Howard lake	408	1010
57	Smith lake	452	1054
59		448	1050
60	Sucker creek (track)	415	1017
60	Sucker creek (water)	392	994
61	Cokato	448	1050
64	Collinwood creek (track)	425	1027
67½		519	1121
68.5	Level of marsh	490	1092
69.5		520	1122
72	Darwin (Big prairie)	530	1132
79	Litchfield station	527	1129
86	Swede Grove station	590	1192
89	Anderson's hill (cut 15 feet)	614	1216
91	Summit (Atwater)	609	1211
92	Cut 10½ feet	639	1241
95.5	Highest point on line (cut 3 feet)	667	1269
98	Very rolling surface to Kandiyohi station	620	1222
105	Willmar station (at Foot lake)	527	1129
110.5	St. John's	519	1121
118	Nearly level to Kerkhoven	506	1108
127	Smooth surface to De Graff station	459	1061
132	Sharp summit (cut 16 feet)	464	1066
134	Gradual descent, smooth surface to Benson station	445	1047
135.5	Chippewa river (bridge track)	433	1035
135.5	Chippewa river (water)	418	1020
140	Gradual ascent, smooth surface, to Clontarf station	442	1044
147	Gradual ascent, smooth surface, to 147's mile post	472	1074
150	Hancock station	553	1155
151.5	Summit	570	1172
155.5	Pomme de Terre river (track)	476	1078
155.5	Pomme de Terre river (water)	464	1066
159	Morris station	527	1129
161	Summit (161's mile post)	554	1156
167.5	Smooth surface to Donnelly station	522	1124
178	Gradual descent, smooth surface, to Herman station	468	1070

St. Paul & Pacific R. R.—Main line—continued.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
184.5	Smooth surface to Mustinka creek	424	1026
185.5	Smooth surface to Gorton	420	1022
194.5	Smooth surface to Tintah	393	995
201	Smooth surface to Rabbit run	380	982
202	Smooth surface to Campbell station	380	982
209	Smooth surface to Doran station	369	971
217	Smooth surface to Breckenridge station	357	959

St. Paul, Stillwater & Taylor's Falls R. R.

COPIED FROM PROFILE IN THE OFFICE OF THE CHIEF ENGINEER, J. S. SEWELL, BY N. H. W.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
0	St. Paul. Low water in Mississippi river	81	683
0	St. Paul. High water in Mississippi river	100	702
1.5	Junction with St. Paul & Pacific R. R.	172	774
	Crossing of L. S. and M. R. R., Phalen's creek (track)	227	829
	Grade of L. S. and M. R. R. here is 20 feet lower	207	809
2	Phalen's creek (bottom) third crossing	201	803
3	Broken surface to second crossing of Phalen's creek (track)	251	853
3	Phalen's creek, second crossing (bottom)	236	838
3.5	Broken surface to first crossing of Phalen's creek (track)	269	871
3.5	First crossing of Phalen's creek (bottom)	251	853
4.5	Broken surface to creek at Ames' farm (track)	321	923
4.5	Creek at Ames' farm (bottom)	290	892
6	Broken ascent to beginning of descent to the Mississippi river (cut 15 feet)	386	988
6.5	Broken surface to tamarack swamp (track)	376	978
6.5	Tamarack swamp (natural surface)	371	973
8	Summit one mile west of Oakdale station (cut 10 feet)	406	1008
9	Oakdale station	377	979
12	Broken surface to the level of Lower Bass lake	284	886
12	Level of Upper Bass lake	298	900
12	Lake Elmo station	331	933
13	Nearly level and smooth surface to road on east line of Oakdale	321	923

St. Paul, Stillwater & Taylor's Falls R. R.—continued.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
15	Summit four miles from Stillwater	327	929
15.5	Junction W. Wisconsin R. R. (cut 17 feet)	285	887
17.5	Broken descent to marsh (bottom)	151	753
17.5	Center of gravel ridge, one and a half miles from Stillwater (cut 50 feet)	171	773
19	Broken descent to high water at Stillwater	85	687
19	Low water in St. Croix lake at Stillwater	65	667

Branch line of the St. Paul & Pacific R. R., from St. Anthony to Brainerd.

FROM THE RECORDS IN THE OFFICE OF THE CHIEF ENGINEER, C. A. F. MORRIS. ABSTRACTED BY N. H. WINCHELL.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
9.5	Junction at St. Anthony	240	842
17	Manomin (Fridley)	246	848
17	Rice creek (water level)	219	821
21.5	Coon creek (water level)	230	832
27	Anoka	281	883
27.5	Rum river (water level)	243	845
34	Itasca	289	891
39	Elk River station	294	896
43	Elk river (water level)	294	896
48	Big Lake station	338	940
56	Becker	375	977
63	Clear Lake station	395	997
73.5	St. Cloud, E. shore of Mississippi river	410	1012
75	St. Cloud, W. shore of Mississippi river	420	1022
	Mississippi river at St. Cloud bridge	363	965
	Mississippi river at Sauk Rapids (water)	386	988
76	Sauk Rapids station	402	1004
82	Watab station	451	1053
85	Little Rock river (track)	418	1020
85	Little Rock river (water)	405	1007
89	Rice's station	457	1059
95	Platte river (track)	467	1069
95	Platte river (water)	457	1059
96	Royalton	478	1080
106	Smooth surface to Little Falls (track)	512	1114
111	Smooth surface to Belle Prairie	528	1130
118.5	Summit	570	1172

Branch line of the St. Paul & Pacific R. R., from St. Anthony to Brainerd—continued.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
120	Fort Ripley	556	1158
120	Nokasippi river (water)	537	1139
127	Crow Wing	584	1186
133.5	Buffalo creek	601	1203
133.5	Buffalo creek (low water)	570	1172
134.5	Summit between Buffalo and Buckhorn creeks	599	1201
136	Buckhorn creek (track)	562	1164
136	Buckhorn creek (low water)	587	1189
137	Broken surface to Brainerd (N. P. Junc.)	604	1206

Line of the St. Vincent branch of the St. Paul & Pacific R. R.

ABSTRACTED FROM THE RECORDS IN THE OFFICE OF THE CHIEF ENGINEER, C. A. F. MORRIS, BY N. H. WINCHELL.

Miles from St Paul.		Above lake Superior.	Above the ocean.
74	E. St. Cloud station	410	1012
74	Low water in Mississippi river at St. Cloud	363	965
75	W. St. Cloud	420	1022
78.5	Sauk river (track)	433	1035
78 5	Sauk river, first crossing (water)	416	1018
79	Sharp ridge (cut 15 feet)	437	1039
82	St Joseph	471	1073
83.5	Watab creek (track)	459	1061
86	Sharp ridge (cut 17 feet)	486	1088
87.5	Broken surface to summit	536	1138
90	Broken surface to Avon	515	1117
94.5	Broken surface to Two rivers (water)	521	1123
6.5	Broken surface to Albany	586	1188
99	Broken surface to summit near 99's mile post	634	1236
101	Broken surface to Getchell's creek (water)	575	1177
103	Broken surface to Freeport (a summit)	624	1226
106	Broken surface to Sauk river, second crossing, (water)	557	1159
108	Broken surface to Melrose	596	1198
111	Smooth surface to third crossing of Sauk river, (track)	598	1200
111	Third crossing of Sauk river (water)	586	1188
114	Broken surface to summit (cut 15 feet), Sec. 24, T. 126, R. 34	656	1258

Line of the St. Vincent branch of the St. Paul & Pacific R. R.—continued.

Miles from St. Paul.		Above lake Superior.	Above the ocean.
116	Broken surface to fourth crossing Sauk river (track)	625	1227
116	Sauk river (low water)	600	1202
117	Smooth surface to Sauk Center station	640	1242
120	Broken surface to cut of fourteen feet	693	1295
121	Broken surface to summit (cut of seventeen feet	712	1314
122.5	Silver creek (track)	666	1268
125	Undulating surface to West Union station	722	1324
131	Broken surface to Osakis station	728	1330
133	Summit (Sec. 22, T. 128, R. 36)	793	1395
135	Broken surface to 135's mile post	727	1329
136	Nelson	754	1356
138	138's mile post	803	1405
139.5	Broken surface to creek (track)	759	1361
142	Broken surface to Alexandria	778	1380
149	Very broken surface to Garfield station	803	1405
158	Broken surface to Chippewa river (track)	760	1362
158	Chippewa river (water)	730	1332
160	Evansville station (cut twenty-eight feet, fill immediately of fifteen feet)	745	1347
161	Very broken surface to summit (cut of thirty feet)	769	1371
166	Very broken surface to lake Christina (cut and fill at Christina of forty-two feet)	623	1225
169.5	Very broken surface to summit (cut five feet)	687	1289
173.5	Very broken surface to St. Oloff	735	1337
176	Very broken surface to summit (cut three feet)	750	1352
179	Very broken descent to Pomme de Terre river (grade)	630	1232
179	Pomme de Terre R. (water)	596	1198
179	Pomme de Terre R. (bottom)	592	1194
180	Broken surface to Tumuli station	596	1198
186.5	Broken and irregular descent to Red river crossing (water)	462	1064
186.5	Red river (bottom)	417	1019
	NOTE.—*From mile post 131 to 188 there are frequent fills and cuts.*		
187	Red River Falls station	522	1124
192	Undulating, slow descent to 192's mile post	499	1101
200	Sec. 1, T. 133, R. 45	467	1069
204	Smooth surface to 204's mile post	464	1066
210	Sec. 15, T. 135, R. 45 (smooth surface)	496	1098
212	Smooth surface to 212's mile post	505	1107
216	Smoth surface to 216's mile post	429	1031
220	Smooth surface to Sec. 31, T. 137, R. 45	419	1021
222	Smooth surface to Barnesville (track)	405	1007
222	Willow river (bottom)	390	992
238.5	Smooth surface, slow descent to Glyndon (N. P. R. R. Junction)	323	925
241.5	Smooth surface to Buffalo river (track)	321	923

Line of the St. Vincent branch of the St. Paul & Pacific R. R.—continued.

Miles from St. Paul		Above lake Superior.	Above the ocean.
241.5	Buffalo river (water)	308	910
241.5	Buffalo river (bottom)	303	905
246	Smooth, level surface to Averill station	317	919
253	Smooth surface to Felton station	315	917
259	Smooth surface to Borup station	311	913
266	Smooth surface to Wild Rice river (track)	309	911
266	Wild Rice river (water)	300	902
266	Wild Rice river (bottom)	295	897
268	Smooth surface to Marsh river (water)	290	892
268.5	Ada station	305	907
280	Smooth surface to Rolette station	293	895
285.5	Smooth surface to Beltrami station	303	905
286	Smooth surface to Sand Hill river	296	898
296	Smooth surface to Kittson station	286	888
302.5	Smooth surface to top of first bluff, Red Lake R.	262	864
302.5	Red Lake river (track on bridge)	266	868
302.5	Red Lake river (water level)	236	838
302.5	Red Lake river (bottom)	224	826
303	Top of bluff on N. side Red Lake river	269	871
	NOTE.—*The valley is just a mile across with single, well defined bluffs.*		
304	Smooth surface, gentle ascent to summit	288	890
310	Smooth surface to 310's mile post	304	906
320	Smooth surface to 320's mile post	286	888
330	Smooth surface to 330's mile post	243	845
332.5	Smooth surface to Snake river water)	241	843
340	Smooth surface to 340's mile post	251	853
343.5	Smooth surface to Middle river (track)	245	847
343.5	Middle river (water)	234	836
343.5	Middle river (bottom)	231	833
350	Smooth surface to Sec. 8, T. 157, R. 48	239	841
351	Smooth surface to Tamarack R. (track,	231	833
351	Tamarack R. (water)	217	819
351	Tamarack R. (bottom)	215	817
375	Smooth surface to S. branch of Two rivers (track).	216	818
375	S. branch of Two rivers (water)	203	805
375	S. branch of Two rivers (bottom)	194	796
380	Smooth surface to North branch of Two rivers (track)	201	803
380	N. branch of Two rivers (water)	187	789
380	N. branch of Two rivers (bottom)	181	783
392	Smooth surface to 392's mile post	196	798
394	Slow, irregular descent to the immediate bank of Red river (track)	189	791
394	St. Vincent (bank of Red river)	190.5	792.5
394	St. Vincent (bottom of Red river)	142	744
394	St. Vincent (high water of 1866)	185	787
394	St. Vincent (usual water surface)	156	758

On the line of the Southern Minnesota R. R.

FURNISHED BY CHIEF ENGINEER H. W. HOLLEY.

Miles from La Crosse.		Above the Miss. R. at La Crosse.	Above lake Superior.	Above the ocean.
	Grand Crossing Miss. R. opposite La Crosse	12	36	638
30	Rushford	96	120	722
48	Lanesboro	215	239	841
53	Isinour's (Sec. 20, T. 103, R. 10)	273	297	899
59	Fountain	676	700	1302
83	Grand Meadow (Sec. 24, T. 103, R. 15)	712	736	1338
	Sec. 13, T. 103, R. 16	788	812	1414
103	Ramsey (grade Mil. and St. Paul R. R.)	588	612	1214
118	Hayward	622	646	1248
166	Winnebago City	470	494	1096
167	Water in Blue Earth river one mile west of Winnebago City	388	412	1014
	Sec. 25, T. 104, R. 30	490	514	1116
	Sec. 1, T. 103, R. 33	599	623	1225
	Sec. 25, T. 104, R. 36	765	789	1391
212	Water in Des Moines river	662	686	1288
	Heron lake (water)	777	801	1403
	Graham lake (water)	819	843	1445
	Sec. 3, T. 102, R. 22	701	725	1327
	Sec. 33, T. 101, R. 21	636	660	1262
	Sec. 36, T. 101, R. 24	608	632	1234
	Sec. 31, T. 101, R. 24	631	655	1257

tirely destroyed and removed the ancient soils. The thickness of this hardpan at Fargo, D. T., on the line of the Northern Pacific railroad, as revealed by the drilling of a well, was found to be one hundred and fifteen feet. It there lies below a hundred and five feet of variously stratified clay, gravel and sand.

This deposit is spread out in a vast sheet over much of the states of Minnesota, Wisconsin, Iowa, Illinois, Michigan, Indiana and Ohio, and it is locally covered by a fine, stratified clay which has been named by the geologists of Canada "Erie clay," although the two have sometimes been confounded. It has never been known to contain fossils, either of vegetables or animals. As clay it is entirely unstratified, but it may embrace irregular beds of stratified materials, and above may become replaced by assorted gravel and sand, the whole being of the same age. As to its manner of deposition it is believed to be the immediate product of the ice of the glacier, and was gently let down on the surface of the rocks that it so effectually conceals, by the slow thawing and withdrawal of the ice. It must have been largely frozen in the body of the ice in regions far to the north, but by the superficial wasting of the glacier as it advanced into warmer latitudes, it gradually formed a layer covering the surface of the ice in much the same way as it now covers the rock. Such underground ice is known to exist at the present time in several places in northern latitudes. Wherever streams of water gathered, incident to the dissolution of the glacial ice, the materials of the drift were assorted and often handsomely arranged in oblique stratification. This would occur especially along the main valleys, and in crevasses that might result from the passage of the ice over rough, rocky surfaces. Streams running in such crevasses would wear their beds deeper into the ice-sheet and perhaps to the bed-rock itself. All drift materials precipitated into such crevasses by the motions of the ice would be washed and assorted, and the finest portions would be entirely carried away. Upon the entire withdrawal, or dissolution of the ice-sheet a ridge of gravel and sand, containing boulders and suggesting the common name of "hog's back," would mark the place where such a stream, had its bed. When the slope of the country was away from the foot of the glacier, or in the direction of its motion, the streams would be likely to carry away the clayey portions of the drift,

leaving only stratified gravel and sand along the valleys of the water courses; but where the slope of the country was toward the ice foot, as in the Maumee valley, in Ohio, and in the valley of the Red river of the North, the fine parts would be laid down over the unstratified drift in horizontal laminations of fine clay and sand. A lake of standing water would be formed about the foot of the ice, with an outlet southward through the lowest drainage valley accessible.* It is authentically reported that at the present time this very circumstance occurs in the Red river valley in seasons of unusual severity. The mouth of the river is completely frozen, or so obstructed by ice, that the whole country for several miles in width is submerged sometimes below forty feet of water. In such cases the discharge must be by the Minnesota valley, Big Stone lake and lake Traverse becoming one. About ten years ago, when these lakes were so united, an effort was made, and nearly with success, to float a steamboat across the continental water-shed from the Minnesota valley into that of the Red river of the North. There are many indications that the Red river region was for a long time covered by a lake of fresh water and had an outlet by way of the Minnesota valley into the Mississippi river.

Overlying this hardpan in much of the southern part of the state, and covering especially those portions of the state where the hardpan exists in small quantities, is a sandy loam which forms a very productive surface soil, and is especially exhibited on the bluffs along the Mississippi river, where it has been named, in states further south, "The Bluff Formation." The distribution of this material over the state is not well known, and its origin remains yet in doubt. Where it reaches its greatest development it is perfectly unstratified. Its characteristics are very uniform, and its aspect and composition are perfectly homogeneous. It has been attributed to the prevalence of a fresh water lake over much of the Northwest. It may perhaps as reasonably be ascribed to the insoluble residue from the rocks *in situ*, and its distribution to the effect of surface drainage. The pulverizing action of the prairie fires on the rocks, or on pebbles contained in the drift may account for the existence of this loam in places where it covers the glacier drift

*Compare "On certain physical features of the Upper Mississippi river." By Gen. G. K. Warren, *American Naturalist* for Nov., 1868.

at points remote from streams. It contains, in the valleys, the shells of the fresh-water molluscs, and seems there to be perfectly comparable to ordinary alluvium. The immediate surface of this loam, and of the soil generally, in the central and southern portions of the state, is blackened by the charcoal of innumerable fires that have passed over the surface, and by decomposing vegetable remains.

The drift about St. Anthony and St. Paul shows the following general section:

No. 1.—Bluff	6 to 10 feet.
No. 2.—Assorted materials, often nicely stratified, sometimes replaced by a mass of glacier-marked (!) boulders and cobble stones mingled with gravel. This seems to be due to the removal by water of the clayey portions of the hardpan. It not unfrequently shows very large blocks and masses of the Trenton flags ("Lower shell limestone," of B. F. Shumard)	10 to 20 feet.
No. 3.—Hardpan, seen	25 feet.

V.

SKETCH OF THE GEOLOGY OF MINNESOTA.

1. GRANITIC AND METAMORPHIC ROCKS.

(a.) *Their area.*

Under this designation are embraced all rocks that lie below the Potsdam sandstone. It covers not only the granitic nucleus which first appeared as dry land, and those trappean rocks that are with little difference of opinion pronounced the result of purely igneous forces, but also the vast thickness of truly metamorphic strata included under the terms *Laurentian* and *Huronian.*

These rocks occupy a great portion of the state of Minnesota, crossing it in a rudely wedged-shaped belt from the northeast to southwest. The southern margin of this belt enters the state from Wisconsin about three miles below the mouth of Kettle river, crosses the Mississippi about three miles below the mouth of Clear Water river in a southwesterly direction. It also crosses the Minnesota river about three miles below Fort Ridgely and probably

MAP OF
MINNESOTA.
Showing the Location of the Counties.
Total area 84,286 square miles.
BRITISH POSSESSIONS
Rainy L.
Hunters L.
Vermillion L.
PEMBINA
BELTRAMI
ITASCA
LAKE
ST LOUIS
POLK
Itasca L.
LAKE SUPERIOR
Duluth
CASS
BECKER
CLAY
WADENA
CROW WING
AITKEN
CARLTON
PINE
OTTER TAIL
TODD
MORRISON
MILLE LACS
KANABEC
GRANT
DOUGLAS
WILKIN
TRAVERSE
STEVENS
POPE
STEARNS
BENTON
ISANTI
BIG STONE
SWIFT
ANOKA
WRIGHT
CHISAGO
LAC QUI PARLE
CHIPPEWA
KANDIYOHI
MEEKER
RAMSEY
WASHINGTON
MC LEOD
CARVER
St Paul
Stillwater
Hudson
Prescott
YELLOW MED.
RENVILLE
SIBLEY
SCOTT
DAKOTA
LINCOLN
LYON
REDWOOD
BROWN
NICOLLET
LE SUEUR
RICE
GOODHUE
WABASHA
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON
DAKOTA TERRITORY
WISCONSIN
IOWA
NORTHERN PACIFIC R.R.
NORTH WISCONSIN R.R.
WEST WISCONSIN R.R.
Mississippi R.
Red River of the North

leaves the state near the northern line of Pipestone county. The northern or northwestern boundary of these rocks enters the state from the north about midway between the lake of the Woods and the Red river of the North, in a southerly and then a southeasterly direction, to the vicinity of Pokegama falls, where it changes its course and runs in a southwesterly direction, passing approximately through Cass, Todd, Stevens and Traverse counties to the western boundary of the state. These rocks thus form a great anti clinal axis, or backbone from which the later sedimentary rocks dip in opposite directions to the southeast, and to the west and northwest, their area being something more than one third of the entire state. North of lake Superior they produce a rough, and even mountainous tract of country which is marked by a series of ridges or ranges of upheaval NE. and SW.; but toward the southwest their original uneven surface is so evenly and deeply covered with drift that they are but rarely seen, except in the valleys of the streams, the country assuming the character of a rolling and more or less wooded, or of a level and open prairie.

(b.) *Their general lithological characters.*

These rocks have been included under the general term of *Azoic*, from the absence of organic remains. The geologists of Canada have, however, described within a few years a strangely concretionary or laminated alternation of pyroxene and carbonate of lime, taken from the *Laurentian system*, which on microscopical examination has disclosed an organic structure resembling that of the *foraminifera*, and has been named *Eozoon Canadense* by Dr. J. W. Dawson.* This discovery carries downward the horizon of the beginning of animal life several thousand feet below the base of the *Potsdam sandstone;* and the appropriate term *Eozoic* has been used to describe the earliest of fossiliferous rocks, comprising the *Laurentian* and *Huronian* systems. With this exception no fossil remains have been found below the *Potsdam sandstone.*

The lithological and mineralogical characters of this belt of granitic and metamorphic rocks are very complex and variable. The original upheaved nucleus was granitic, or syenitic and granitic, and this character prevails in the oldest and highest knobs and hills, around which the highly metamorphosed slates and gneisses

*In this fossil the pyroxene is sometimes replaced by serpentine, or loganite, (or by pyralolite?) and the calcite by dolomite.

are arranged in upturned and even vertical beds. Intercalated with these disturbed beds are numerous injected beds and dykes of volcanic trap, the igneous origin of which cannot be doubted. The metamorphism consists in a decomposition and recrystallization, through the combined action of heat and chemical affinity, of the first sedimentary strata, producing from sandstones, limestones and shales, talcose argillaceous slates, gneiss, quartz and saccharoidal marble, and in some instances immense masses of specular and magnetic oxide of iron. The close of this disturbance involved the overlying *Potsdam sandstone*. or at least the "red sandstones" of the Northwest, but in Minnesota it antedates, so far as known, the sandstones of the St. Croix valley and the *Lower Magnesian limestone*. It seems to have continued to the close of the deposition of the "red sandstone," and to have terminated prior to the deposition of the Lingula beds, which lie without disturbance, as far as known, on the ejected traps, and between the red sandstone and the light-colored quartzose sandstone which characterizes the upper Mississippi valley. This disturbance was the cause of fissures and dislocations in the rocky crust, which by slow degrees became filled with the various materials composing the metalliferous veins.

In 1849 Col. Charles Whittlesey classified these rocks in northern Wisconsin, in the following desecending order: (*Owen's geol. sur. of Wis., Iowa and Minn., p. 425.*)

1. SEDIMENTARY.
   a. Red sandstone (*not belonging to the metamorphic series.*)
   b. Black slate.
   c. Conglomerate.
2. TRAPPOUS ROCKS, OR THOSE OF VOLCANIC ORIGIN.
   a. Black and red amygdaloid, and greenstone trap.
   b. Augitic, hornblendic and feldspathic rocks, embracing syenites and granites of the same age.
3. METAMORPHOSED ROCKS.
   a. Hornblendic slates.
   b. Iron slates.
   c. Black slates, in large, thin, rectangular sheets.
   d. Talcose slates.
   e. Slaty quartz.
4. GRANITIC.
   a. Syenite.
   b. Granite occupying the country south of the mountain range or uplift, and are the oldest rocks seen.

Messrs. Foster and Whitney, in a report on the lake Superior land district in 1851, give them the following arrangement in descending order:

AZOIC SYSTEM.
Beds of quartz and saccharoidal marble.
Chlorite, talcose and argillaceous slate.
Gneiss, mica and hornblende slate.
IGNEOUS ROCKS, OF VARIOUS AGES.
Trappean or volcanic rocks.
Masses of specular and magnetic oxide of iron.
Hornblende and serpentine rocks.
Basalt, amygdaloid.
Greenstone, or doleryte, porphyry.
Plutonic rocks.
Feldspar and quartz rock.
Syenite.
Granite.

The *Potsdam sandstone*, or that portion which is equivalent to the red sandstone, overlies all the forgoing, and although very much broken by intrusions and overflows of trap, and often reduced to the form of a conglomerate, or a volcanic tufa, is not regarded by Foster and Whitney as belonging to the series of metamorphic rocks.

(c.) *Their economical value.*

In the state of Minnesota these rocks are known to contain variable quantities of gold, silver, copper and iron. As yet no extensive exploitation of these metals has been made. Veins of gold and silver bearing quartz are known to occur in the vicinity of Vermilion lake, and at other places on the north shore of lake Superior. Recently gold has also been reported from the vicinity of Red lake. Veins carrying native copper, as well as the sulphuret and carbonate, also occur on the Kettle river, and at Taylor's Falls on the St. Croix river. Iron ore in unlimited quantities is said to exist in the dividing ridge between lake Superior and Vermilion lake. Other materials of economic importance also pertain to these rocks. The gray "granite" quarried at St. Cloud contains both mica and hornblende (or pyroxene); the quartz is slightly amethystine, or smoky, and makes up about one half the bulk of the whole, while unmistakable feldspar is almost entirely wanting. It has also a very few minute crystals of pyrites. It is being considerably introduced into some of the largest structures both in St. Paul and Minneapolis, and in various cities of the Mississippi valley. Its composition renders it a very durable building material, even more enduring than typical syenite or granite. Roofing slate is also one of the economical products of the metamorphic rocks, known to exist in Minnesota. There is no doubt but unlimited quantities of this

material will yet be found within the state. The efforts that have hitherto been made to manufacture this article and introduce it into the markets of the Northwest, in the vicinity of Thomson, have not been very successful. It is believed, however, that the fault lies not in the material itself, but in the manner it has been handled. For fire-stone the talcose slates, associated with the Huronian series in the eastern extension of these rocks in Michigan and Canada, are very well adapted. These rocks also ought to supply steatite, or soapstone, and no doubt hold considerable beds of variegated and saccharoidal marble. It will be a prominent object, in the progress of the survey, to bring these various economical resources into careful observation and investigation. At the present time little is known beyond the foregoing statement of facts, although private parties have made more or less detailed surface exploration.

2. THE POTSDAM SANDSTONE.

(a.) *Preliminary considerations.*

This term is strictly applicable only to the sandstones of New York state, to which the name was first given, and to the equivalents of those strata in their extension through the west. It has been abundantly proved that the red sandstones of lake Superior, however disturbed and changed locally, or however much increased in thickness by the agency of volcanic outbursts, are the exact equivalents of the New York *Potsdam.* They occupy the first position over the metamorphic slates of the *Huronian* rocks on which they lie unconformably, and from which they differ in being but slightly and only locally metamorphosed. They retain usually their evidently sedimentary characters, and have not well preserved fossil remains. By the Canadian geologists the term *Potsdam* is made to cover a group of arenaceous strata, the lower portion only of which is the real equivalent of the New York Potsdam.*. In Michigan the name is given only to the red sandstones, the overlying light colored sandstones being regarded as a part of the *Calciferous sandrock.*** Dr. Houghton as early as 1841 distinctly stated in his annual report to the Michigan Legislature, that the "upper gray sandstone" is not conformable with the "lower or red sand-

* See *Geology of Canada*, 1863. p. 87.

** See *Biennial report of progress*, 1860, p. 49.

stone and shales." (See his report for 1841, p. 19.) In Wisconsin the same sandstone occupies a wide circular belt surrounding a granite center. The overlying light-colored sandstones are found there to lie unconformably on the red sandstones where they have been tilted by volcanic agency.† Dr. C. A. White, of the geological survey of Iowa, has described a red sandstone or quartzyte, occurring in outcrop on the Big Sioux river and in southwestern Minnesota, and given it the special name of *Sioux quartzyte*, proving conclusively that it is both older, and unconformable with the light-colored sandstones that occupy a conspicuous place in the bluffs of the upper Mississippi, below the *Lower Magnesian limestone*.†† At New Ulm, and and at other points in southwestern Minnesota, the same quartzyte forms some of its characteristic outcrops. It rises suddenly above the superincumbent drift, exposing at New Ulm about 350 feet, with a dip of thirty-six degrees to the north. Its features here are easily identifiable with those of the *Potsdam* at the rapids in the St. Mary's river, at Sault Ste. Marie, Mich. In their passage to the west the overlying light-colored sandstones seem to become more largely developed. They acquire a thickness, including the intercalated beds of shale, of about six hundred feet, in their exposures along the Mississippi river.

On the other hand Dr. D. D. Owen, finding these upper sandstones abutting undisturbed against the trap outbursts at the falls of the St. Croix, supposed at once that he reached there the true paleozoic base.‡ Fossils gathered there, and at other points on the upper Mississppi, in these and associated beds, were described as coming from the *Potsdam sandstone*, and were supposed to belong to a horizon much lower than that of the *Lingula beds* of the *Potsdam* of New York. The name has been still further removed from its original use by the Iowa geologists, *in its application only to these upper beds*, and in giving the name *Sioux quartzyte* to the western representative of the original *Potsdam*. Dr. Owen, although he recognized many points of difference between the lake Superior and New York *Potsdam*, and these light-colored sandstones of the St. Croix and upper Mississippi, seems not to have noted the important fact that the former are everywhere subject to distortions and fractures by volcanic forces, while the latter are

† R. D. Irving, on the Age of the Quartzytes, &c., of Sauk county, Wis., *Am Jour.*, Feb., 1873.

†† *Geology of Iowa*, 1870. Vol. I., p. 167.

‡ *Geological report on Wisconsin, Iowa and Minnesota*, p. 50.

never known to be disturbed by such causes. It is true that he embraces both the red and the light-colored sandstones in the designation of "Potsdam," and argues at length to prove the greater age of the red.*

It is in accord with geological precedent, therefore, to separate these two sandstone formations under different names, retaining the name of *Potsdam* for the older, and giving provisionally the name of the St. Croix river, on which they are best exposed, to the latter:

The following reasons may be assigned:

1st. The *Potsdam* beds were laid down before the close of the volcanic disturbance so evident in the rocks of the early Silurian and pre-Silurian ages; the *St. Croix* beds were deposited and still lie in horizontal layers, unconformably not only over the *Laurentian* and latest trappean rocks of the Northwest, but also on the upturned beds of the *Potsdam.*

2nd. The observations of the New York and Canadian geologists place the earliest *Lingula* beds near the top of the *Potsdam sandstone;* this separation of the *St. Croix* beds does not invalidate their conclusions, but fixes the *observed* paleozoic base in the Northwest at some point higher than that of the *Potsdam.* The wonderful abundance of fossil Lingulas and other forms in the shale abutting against the trap at the falls of the St. Croix would furnish presumptive evidence of their existence prior to that outburst. They simply have not been seen.

3d. The lithological characters of the *Potsdam* beds are uniformly different from those of the *St. Croix* beds. The former are hard and often vitreous, usually of a brick-red color. Their bedding is very distinct, and often separated into slaty layers by partings of red shale. They are strongly marked by the so called fucoidal impressions. They are frequently ripple-marked and sun-cracked. The latter are white or buff-colored, often friable, and constitute a heavy bedded or massive sandstone, of handsomely rounded quartzose grains.

4th. They differ in chemical composition. The *Potsdam* beds contain "a considerable percentage of alumina, ranging sometimes as high as twenty per cent., while of silica there is often less than fifty per cent. Their peculiar red color is due to the presence of a large proportion of peroxide of iron, with a much smaller proportion of protoxide" (Owen).

**Geological survey of Wisconsin, Iowa and Minnesota,* p. 187.

The *St. Croix* beds "commonly contain ninety-two per cent. and upward, of silica, while of alumina and oxide of iron taken together they have seldom more than three per cent" (Owen).

5th. They are separated by a fifty-foot bed of *Lingula shale* which lies at the bottom of the *St. Croix* beds.

6th. The *Potsdam sandstone* has a thickness of at least four hundred feet;* the *St. Croix sandstone* also has a thickness of over five hundred feet. It is more in keeping with the canons of geological nomenclature to give separate titles to formations so well defined and so largely developed.

7th. The evidence of paleontological difference is perhaps the strongest reason for separating these sandstones. The fossils of the *Potsdam sandstone* in New York are *Lingula antiqua* (Con.) and *Lingula prima* (Con.), a *Discina* (or *Orbicula*), and uncertain impressions supposed to be of a *Pleurotomaria* and of crinoidal remains. A species of *Theca* has also been described from Keeseville. According to Prof. James Hall but three species are known from the Potsdam of New York. (Foster & Whitney's *report on lake Superior*, Part II. p. 230). The fossils of the *St. Croix sandstone* are, according to Dr. Owen, (*Rep. on the geological survey of Wisconsin, Iowa and Minnesota*, p. 624) the following:

Dikelocephalus Minnesotensis, (On.)	For. 1. d.	5th trilobite bed,	90 to 100 feet below	F. 2.
" *Pepinensis*, (On.)	" "	" "	"	"
" *Miniscaensis*, (On.)	" "	3rd "	200 to 220 feet	"
" *Iowensis*, (On.)	For. 1. b.	1st trilobite bed	more than 500 feet	"
" *granulosus*, (On.)	For. 1, d.	3rd " "	200 feet	"
Lonchocephalus Cippewaensis, (On.)	"	3rd or 4th " "	?	"
" *hamulus*, (On.)	For. 1. d.	3rd "	200 to 220 feet	"
Crepicephalus Minnesotrnsis (On.)	" "	"	"	"
" *Wisconsensis* (On.)	" "	"	"	"
Monocephalus Minnesotensis, (On.)	" "	"	"	"
Euomphalus (*species undet.*)	For. 1 f.	6th "	50 feet	"
Lingula pinnaformis, (On.)	" b.	*Lingula shales*,	600 feet	"
Lingula prima, (Con.) ?	" ?	"	"	"
Lingula ampla, (On.)	" c.	"	"	"
Lingula antiqua, (Con.)	" ?	"	"	"
Orbicula prima, (On.)	" c.	"	"	"
Obolus Apollinis,	" d.	?	?	?
Orthis (species ?),	" d.	?	?	?
Crinoidal remains,	" d.	?	?	?

To these Mr. Hall adds from Wisconsin.†

Lingula polita, (H.)
" *Aurora*, (H.)
Theca primordialis, (H.)
Serpulites Murchisoni.
Graptolithus Hallianus, (Prout.)
Conocephalites, (two species.)
Arionellus.
Agnostus.
Platyceras.
Orthis Barabuensis, (H.)
Orthis, (species?)

*Dr. Owen makes the thickness of the Potsdam (red sandstones of lake Superior) over five thousand feet. See Owen's *Report on Wis., Iowa and Minnesota*, p. 193.

†*Geology of Wisconsin* vol. I., p. 20.

The "Menominee trilobite bed," of Foster and Whitney is placed by Owen in the *St. Croix sandstone.* Of all the above species the real *Potsdam sandstone* has afforded in New York but three species and those of genera that range not only through the Lower Silurian, but have maintained an existence to the present time.

8th. Messrs. Foster and Whitney, recognizing the paleontological difference between the *Potsdam sandstone* of New York and the *St. Croix sandstone* of the Northwest, yet laboring to prove their horizontality, suggest that the striking fossils of the latter may yet be found in the *Potsdam* of New York,† having been hitherto overlooked. It would seem more likely that the few fossils of the eastern *Potsdam* have escaped the eye of western geologists in examining rocks of that horizon, than that the singular forms of animals found in the *St. Croix sandstone* of the west have escaped the eye of eastern geologists. The following table of the number of species found in the state of New York, and the lake Superior district is of interest in this connection. It was prepared by Prof. James Hall, and is published in Foster and Whitney's *Report on the lake Superior land district.* Part II, p. 230.

	Lake Superior district.	New York.	
Potsdam sandstone	3	3	
Calciferous sandstone	4	13	
Chazy limestone	10	45	
Birds Eye, Black River and Trenton	64	220	And thirty species common to the Trenton and other groups.
Hudson River group	31	54	Besides thirty other species common to this and the preceding groups.
Clinton group, Niagara group	26	298	
Upper Helderberg	16	?	

Inspecting this table we see the number of fossils found in the *Potsdam* in the west, including also those enumerated by Mr. Hall from the *St. Croix sandstone*, is equal to those from the *Potsdam sandstone* of New York. From the *Calciferous* the proportion of fossils found in New York is 225 per cent. in favor of eastern geologists. From the *Chazy limestone* the proportion is 350 per cent. in favor of eastern geologists. From the *Birds Eye*, *Black River* and *Trenton* limestones the proportion is 244 per cent. in favor of eastern geologists. From the *Hudson River group* the proportion

† Foster and Whitney's *Report on the lake Superior land district.* Part II, p. 134.

is 74 per cent. in favor of eastern geologists. From the *Clinton* and *Niagara groups* the proportion is 1050 per cent. in favor of eastern geologists. From the *Upper Helderberg* the proportion is not known, but probably would exceed the per cent. of any of the other formations, in favor of the eastern geologists. This only shows the greater scrutiny with which the formations have been observed in New York than in the lake Superior district, and inferentially that the fossils of the *St. Croix sandstone* have not been overlooked in New York. It seems more reasonable to suppose the *St. Croix sandstone* is only another illustration of the intercalation of arenaceous sediment in the Lower Silurian of the Northwest, creating really a new member of that series of rocks and introducing its own fossils, and that the paleozoic base of the *Potsdam* in New York has not yet been observed in the Northwest.

Notwithstanding these considerations it has not been thought best to attempt the delineation of the areas of these sandstones separately on the preliminary geological map accompanying this report. They are there colored as one formation, under the double designation of *The St. Croix and Potsdam sandstones.*

According to Dr. Owen the following table shows the most persistent elements of stratification of these great sandstone formations. [See *Geol. rep. on Wis., Iowa and Minn.*, p. 52].

f.	Sixth trilobite bed.	Quartzose, light-colored sandstones of various degrees of induration, with intercalations of beds of magnesian limestone, with glistening, crystalline facets and calcareo-siliceous oolite produced by rounded grains of quartz encased in calcareous cement. containing *Euomphalus* and imperfect trilobites. Locally with a band of green earth	ft. 50 to 85
		Mammillary and botryoidal layer of white sandstone: sometimes banded with yellow...	5 to 6 inches.
e.		Thick beds of soft, yellowish and brown sandstone, sometimes with botryoidal, hard, projectig concretions; passing downward into fine-grained, soft sandstones approaching tripoli.................................	ft. 40 to 50

			FT.
	Fifth trilobite bed.	Ash-colored and yellowish argillo-calcareous and magnesio-calcareous beds, containing *Dickelocephalus Minnesotensis*, Stillwater trilobite bed....	8 to 10
		Green, red and yellowish sandstones with thin, schistose, dolomitic intercalations	40
		Upper, brown dolomitic layers, containing *Orthis*, *Lingula*, and columns of *Crinoidea*, as at La Grange mountain	4
	Fourth trilobite bed.	Alternations of yellow, laminated sandstones with green particles disseminated	5
d.		Marine Mill trilobite grit	5
		Fucoidal layers, and thin-bedded green and yellow sandstones: at their base often a band of about six inches of green earth used by the Indians as a pigment	30 to 40
		Green and red sandstones charged with silicate of iron	5
		Loose green sand, and soft green sandstone	15
	Third trilobite bed.	Micaceous sandstone containing *Dikelocephalus Miniscaensis*, *D. granulosus*, &c	3
		Alternations of green and ferruginous sandstones	20
		Micaceous sandstones containing *Dikelocephalus Miniscaensis*, &c	2
		Thin layers of green sand alternating with green earth, impregnated with silicate of iron	30 to 40
		Lower, brown siliceo-calcareous and dolomitic bands of Mountain island and elsewhere	4
		Soft, thin-bedded sandstones with scales of mica disseminated	10 to 15
c		Coarse Lingula grit, green, yellow, sometimes almost white	100 to 130
	Second trilobite bed.	Fine grit, place of the Menominee trilobite grit (?), white and yellow sandstones and *Obolus* layers of Black river	15
b.	First trilobite bed.	Ferruginous trilobite grits, schistose sandstone containing fork-tailed trilobite beds and *Obolus* layers	1 to 8
		Magnesio-calcareous rock with *Obolus* and fork-tailed trilobites	3
		Highly fossiliferous, schistose, siliceo-calcareous layers interlaminated with argillaceous, marly beds, charged with sulphate of iron; the former full of *Lingulæ* and *Orbiculæ*. Falls of the St. Croix	50
a.		Sandstones with oblique lines of deposition, alternating with pebbly sandstones and coarse grits of the Chippewa, Black and Wisconsin rivers, near the falls	50 to 100
		Place of the lake Superior ferruginous and argillaceous sandstones, shales and conglomerates	5000

(b.) *Area of the St. Croix and Potsdam sandstones.*

The area here described embraces that of the light-colored quartzose beds of the St. Croix and upper Mississippi valleys, and of the ferruginous and often metamorphosed red sandstones which lie below them. It can only be defined approximately. It is separated by the area of the granitic and metamorphic rocks into two belts, one lying along the southeast side of that area and the other along the northwest side. The former has a width on the St. Croix river extending from about four miles below the mouth of Kettle river to a point about six miles below Franconia. It runs diagonally across the state toward the southwest, including the counties of Chisago, the southern part of Pine, Isanti, the northern half of Anoka, the most of Sherburne, Wright, the western half of Carver, the eastern half of McLeod, the central portion of Sibley, the most of Nicollet, the northwest corner of Blue Earth, the greater portions of Brown and Watonwan, Cottonwood, Murray, Pipestone and Rock, with the northern portions of Jackson and Nobles. The northwestern area of these sandstones is supposed to include the counties of Traverse, Grant, Otter Tail, the northern halves of Douglas and Todd, Wadena, the most of Cass, and the central portions of Beltrami and Pembina. There are likewise isolated outliers of these sandstones even within the area of the granitic and metamorphic rocks, and a small area also in the eastern part of the state, in Carlton and St. Louis counties, near the western extremity of lake Superior.

(c.) *Lithological characters of the St. Croix and Potsdam sandstones.*

The general lithological characters, and the differences between the *St. Croix* and the *Potsdam* sandstones have been sufficiently set forth under the head of *Preliminary considerations.* It only remains to add special sections observed.

The lowest rock observed within the state, lying above the slates of the metamorphic series, is believed to be the red quartzyte seen at Redstone, near New Ulm. Such stone is said also to occur on the upper tributaries of the Cottonwood, viz: on Dutch Charley's creek, T. 108, R. 37; also on a branch of the Watonwan creek, T. 107, R. 34. At the former place it is now quarried, and is about to be at the latter. These places, however, have not been visited, though the characters of this quartzyte are so striking that the most unskilled observer could not fail to identify the stone. At

Redstone the beds are tilted at an angle of 35 to 40 degrees toward the north, showing their jagged edges which stick out along the north bank of the river. The exposed rock rises, a short distance north from the river banks, to a hight of 150 to 250 feet above the lowest exposed beds. In these bald, lichen-covered knobs the dip is maintained to the north at the same angle, making as much as 350 feet of stratification exposed. The surface of these knobs, and in general the surface exposure of the whole, is much more indurated and quartzitic than those lower beds that have been opened by quarrying and by the cutting for the railroad grade. It appears as if the greatest metamorphism had taken place over the surface, the lowest strata seen being more perfectly bedded and thinner, as well as argillaceous and wave-marked. The whole is of a reddish color, varying from brick-red in the lower beds, to a dark-red or purplish hue, in the highly metamorphosed portions. It sometimes shows a finely pebbly structure, and some small spots of a softer texture, which on fracture have some appearance of a greenish impure chert, or of a serpentinous or epidotic composition. These greenish spots are closely impacted in, or chemically united with the mass, as if derived from it. Other parts are more plainly a sandstone, much less glassy on fracture, showing all the characters of the *Potsdam sandstone*, as recognized in the lake Superior district. The following characters indicate the *Potsdam* age of this outcrop of red quartzyte.

1. Its red color, spotted with lighter color. even to cream color.
2. Ripple marks and mud cracks.
3. Worm-marks and fucoids.
4. Thin laminæ of shale separating the beds.
5. The very observable and regular bedding.
6. The impossibility of setting any limit between the evidently sandy and sedimentary portions and the quartzitic and metamorphosed portions. They pass one into the other in the distance of twenty feet.
7. The highly inclined position of the strata.
8. Its *arenaceous* character, taken as a whole, in distinction from the talcose and slaty, or the hornblendic and the micaceous nature of the *Huronian*.

A singular phenomenon was observed on these knobs, indicating the recent activity of volcanic forces. About sixty rods north from the railroad cut the superficial heavy quartzitic beds are tossed up on their edges in opposite directions, over a space of a couple

of square rods, some blocks of ten feet long and four or five feet thick, standing exactly on their edges near the point of outburst. These pieces are all lichenous and weathered, indicative of the great age of their exposure in that condition. The whole place looks very much as the tilted beds in a quarry immediately after the discharge of a blast of gunpowder. In the center of the place where the beds are most disturbed and broken fissures and openings in the deeper seated strata may be seen, while one large opening descends down nearly perpendicularly into the rock. The positions of these loose pieces which are undeniably torn from the beds near where they lie, indicate the operation of some powerful subterranean force since that part of the state was subjected to the levelling process of glacier ice.

The *Lingula shale*, at the falls of the St. Croix river, is believed to hold a place stratigraphically above the sandstone at New Ulm, although at that place a trap outburst entirely screens the actual superposition from observation. These shale beds there abut conspicuously and almost horizontally against the trap rock which rises on nearly all sides to the hight of two or three hundred feet. At the village of St. Croix Falls a little creek enters the river at the foot of Georgia street. Just as it joins the river it passes over six or eight feet of green shale filled with *Lingulæ* and *Orbiculæ*, of which there seem to be several species. The shale is extremely rusty with iron in all crevices and partition planes, owing probably to the oxidation, by the running water, of the fine crystals of pyrites, with which much of the shale is crowded. After an obscured interval of several feet, believed to be occupied by this shale, at a point further up the creek, the water passes over about ten inches of coarse, rusty sandstone. Still further up this creek probably similar shale underlies the immediate surface. Yet the hills of trap rock rise suddenly within a quarter of a mile of the river, to the hight of over 150 feet. Further up the river, other creeks, entering from the east, expose the same shale along their sides, or in their beds. At one point the immediate bank of the St. Croix river shows, at the village of St. Croix Falls, a thickness of 49 ft. 8 in. of horizontal bedding, measured by Locke's level. The dry, weathered surface of this bluff has an ashen color, yet exudes a substance which on becoming dry is yellow and has much the taste of alum. There are also interlaminated thin layers of arenaceous

shale or sandstone, more enduring. These, lying in fragments at the foot of the bluff, show surfaces that are almost completely covered with the broken or entire valves of fossil *Lingulæ* and *Orbiculæ.* These fossils pervade the whole thickness of this shale, so far as here seen, and they seem to have gathered in unwonted abundance in the isolated depressions or basins of the original traprock surface. Occasional rude septaria of impure blue limestone also contain, but in less quantities, the same fossil bivalves.

Section at Winona, in Winona county.

In ascending order the next section observed is that of the bluffs at Winona. It includes also a part of the *Lower Magnesian limestone.* It shows the following stratification in descending order:

No. 1.—Slope from the summit to the brink of Observatory bluff (character of rock unknown)		20 ft.
No. 2.—Arenaceous breccia, or conglomerate, belonging to the *Lower Magnesian limestone,* with considerable calcareous matter, especially in the form of patches of calc-spar and some very hard, gray limestone, which is often variegated in colors of red, greenish and pink. It contains also chert and colored flint; but the flint seems to be united with the matrix as if produced by chemical secretion like the calcite. This rock forms the bold buttresses which in many places round out the summits of the bluffs and form their prominent angles, as at Castle Rock, on the Wisconsin side, and on Observatory bluff opposite the normal school. At the railroad cuts, above Stockton, it stands out in isolated pinnacles and towers. It has the outward aspect of a rough, cavernous and concretionary breccia		35 ft.
No. 3—Heavy, regular beds of *Lower Magnesian limestone.* These layers are of a cream color, hard and enduring, and somewhat vesicular, but very extensively wrought for building. Of these beds 99 ft. 4½ in. are seen in the singular outlier known as *sugar loaf*		145 ft. 6 in.
No. 4.—Interlaminations of limestone with sandstone, belonging to the *St. Croix sandstone.* The details of the stratification here are as follows, in descending order:		
(a.)—Homogeneous, incoherent, white sandstone, very similar to the *St. Peter sandstone*	2 ft.	
(b.)—Hard sandstone, with considerable calcareous matter, having much the aspect of the overlying limestone with masses of common calc-spar	8 ft.	
(c.)—Friable sandstone, white	2 ft.	
(d.)—Same as (b)	5 ft.	
(e.)—Loose, sandy shale, with fragments of light green shale in scales	1 ft. 6 in.	
(f.)—Same as (b)	3 ft.	
(g.)—Same as (a)	1 ft.	

(h.)—Same as (b), almost a pure and crystalline dolomite	6 ft.	
(i.)—Same as (a), very coarse grains of rounded sand, consisting of purely white quartz, with lenticular beds and masses of limestone	10 ft.	
(j.)—Same as (i), but more calcareous and projecting	20 ft.	
(k.)—Sandstone; massive, with little or no calcareous matter	12 ft.	
(l.)—Calcareous layers, and thin sand layers alternating as above, the greater portion being sand, aggregating about	55 ft.	
These alternations make up (e) and (f) of Owen's general section (see p. 73)		125 ft.
No. 5.—Massive mural sandstone, passing below a talus, seen		20 ft.
No. 6.—Interval, unobserved, hid by talus (covering (d) of Dr. Owen's general section)		226 ft. 3⅛ in
No. 7.—Hard, massive, ferruginous sandstone, containing *Lingula* ((c) of Dr. Owen's general section?) This is seen near the base of the escarpment, nearly a mile above Observatory bluff, seen		8 ft.
No. 8.—Sloping talus, to the level of Winona lake		15 ft.
Total hight of bluffs		594 ft. 9⅛ in.

Although other sections covering more or less of the *Potsdam* and *St. Croix* sandstones have been taken at different places, yet nothing has been observed throwing additional light on the relations of these two formations, and they are withheld till the proper time for reports on detailed work by counties.

(d.) *Fossils of the St. Croix and Potsdam sandstones.*

It has already been stated that the only fossils found in these sandstones pertain to the upper or St. Croix, and that in the lower which is more probably the real equivalent of the *Potsdam sandstone* of New York, no well defined fossil remains have yet been discovered in the state of Minnesota. The obscure fucoids and worm-marks have indeed been seen; but their real origin may be regarded as yet undetermined. For a list of fossils found in the the St. Croix beds, in the state of Minnesota, and enumerated by Dr. Owen, the reader may consult a former page entitled "preliminary considerations."

(e.) *Economical value of the St. Croix and Potsdam sandstones.*

The *Potsdam sandstone*, in the vicinity of lake Superior where invaded by the disturbance of trap outbursts, is known as the most

highly cupriferous rock in the United States. This is not because the rock itself in all places is liable to contain copper, but is owing to the agency of igneous and perhaps to other metamorphic forces. It is also confined to the lower portion of the formation, and is accompanied with the various forms of volcanic rock and conglomerate. What amount of copper it may carry in the northern part of the state of Minnesota is entirely unknown. As it occupies a considerable area where the beds are known to have been highly tilted from a horizontal position, it is not unreasonable to suppose that copper in considerable quantities may yet be found. The Potsdam has also very often supplied a stone for building purposes of a very superior quality. The lake Superior "brown sandstone" is from rocks of this age. It is believed that the use of sandstone in important structures is to become much more prevalent than formerly, and any available outcrop of this rock ought to be fully proved for stone of this kind. The nearest and most accessible exposure of this kind for the markets of central and southern Minnesota is that at Redstone, near New Ulm. As it is reached directly by railroad, it is safe to say the time is not far distant when the markets of the state will be able to furnish stone from this vicinity of a quality equal to any found in the Northwest. It will also supply a vast extent of country in northern Iowa which is largely destitute of stone suitable for purposes of construction.

Some portions of the *St. Croix sandstone* have been quarried for building purposes, and at Taylor's Falls it has been used in one or two business blocks. It is of rather coarse grain and friable on first quarrying, but the weather operates to harden it in a few months. It is of a lighter, pleasanter color than the *Potsdam.* Except for the manufacture of glass, for which much of the light sandstones of the St. Croix beds is suitable, and favorably exposed along the Mississippi river,* it is not known that there is any other important use to which these formations may be put. Some of the clays, especially those stained with iron, may be made useful for pigments, and the bed of red *catlinite*, used formerly by the Indians in Pipestone county, takes a polish which will render it valuable for small ornaments.

*At Red Wing Mr. Pascal Smith so utilizes this formation, shipping it by barges down the Mississippi to points in Illinois.

3. THE LOWER MAGNESIAN LIMESTONE.

(a.) *Its area.*

Beginning at the southeastern corner of the state where this limestone forms the summits of the bluffs of the Mississippi and supports the high table-land that extends westward from the river, this formation occupies a belt of irregular width along the west side of that river to a point a little above Hastings, where its western limit crosses the Mississippi. The eastern edge of this belt runs along the east side of the Mississippi, including considerable of the state of Wisconsin. Hence it underlies the most of Houston county, the northeastern part of Fillmore, the eastern half of Winona, nearly the whole of Wabasha, and the eastern portions of Goodhue and Dakota. North of the Mississippi this belt curves more to the west, bringing its eastern margin across the St. Croix river a few miles below Franconia. Passing westward this limestone underlies the northern and eastern portions of Washington county, the central portions of Anoka, Hennepin and Carver, the most of Scott and Le Sueur, the eastern portions of Sibley and Nicollet, the central portions of Blue Earth and Martin and the southern portions of Jackson and Nobles. In the northwestern part of the state an area is supposed also to be underlain immediately by this limestone, but its limits are entirely conjectural, so far as they are expressed on the accompanying preliminary map. The same is true in respect to the boundaries of this limestone in the southwestern part of the state.

(b.) *Its general lithological characters.*

The eastern name of this limestone is *Calciferous sandrock*, so named from the intimate mixture of dolomitic and arenaceous ingredients. In Minnesota, however, a large proportion of this member of the Lower Silurian is a truly magnesian limestone, and almost free from sand. In some places heavy and continuous layers of white sand are found between equally heavy and persistent layers of limestone; while throughout the whole thickness of the formation the uniformity of the bedding is liable to interruption by the inexplicable occurrence of isolated masses of breccia, or cavernous conglomerate, in which the arenaceous and calcareous qualities are intimately and confusedly mixed. The lower beds are

often abundantly interstratified with and broken by more or less continuous bands of chert. Distinctly oolitic characters also sometimes prevail. Its color is light, varying from a cream-color or light-buff, to a pinkish salmon. While much, even of the most evenly bedded portions of this limestone, is somewhat vesicular or shows spar-lined cavities, its general firmness is very great, and it forms the prominent angles to the summits of the bluffs on either side of the Mississippi below the confluence of the St. Croix. These even and heavy layers are those usually quarried for building-stone, while the less regular and concretionary parts are better adapted to lime-making, both from the greater ease with which the beds may be removed and their comparative freedom from sandy and clayey impurities.

The following sections have been taken from exposures of this limestone, in addition to that given in connection with the underlying sandstone, at Winona (p. 78), and will further elucidate the lithological characters of the formation.

Section at Quincy, in Olmsted county.

Taken near the dam, in descending order.

No. 1.—*Lower Magnesian limestone;* quite arenaceous, falling out in huge masses which are rough, distorted in their crude bedding, and unmanageable as a quarry-stone, showing much calc-spar. Limestone and sandstone are mingled with occasional strips of a light-green shale. In general the face presents the appearance of an alternation of horizontal layers of thin and more shaly beds, with heavy, coarse and rough limestone beds. Some green shale layers alternate with dark umber-colored (ochreous) shale, neither being more than two inches thick. They are tortuous and not continuous. This phase appears like the tops of the bluffs at Winona, but is probably at a considerably higher horizon	30 ft.
No. 2.—Persistent, white sandstone or granular quartzite, seen	10 ft.
Total exposure	40 ft.

Section at Shakopee, in Scott county.

The quarries at Shakopee for lime-burning expose about twenty-five feet of stratification, though the bedding is much confused and almost obliterated by chemical and other metamorphic agencies. The stone is very rough and very often a true breccia. It is somewhat arenaceous, and also argillaceous. Some small, shapeless cavities are filled with a greenish shale, which, if indurated, would be like some flinty spots often seen in the same formation, as at Winona. Some of this shale is so hard as to have conchoidal fracture, and some is so soft as

to be like wax or putty in the fingers. It varies through different shades of green and blue. It seems to be intimately blended in texture with, and insensibly passes into, the compact limestone of the most fine-grained portions of the quarry. It is not a common ingredient. Some other cavities are lined with incrustations of mammillated and drusy quartz. Exposed about........................ 25 ft.

Section at Mankato, in Blue Earth county.

(Quarry of Maxfield and Sons: in descending order: gentle dip N. E.)

No. 1.—Porous magnesian limestone, not used........... ....4 to 6 ft.
No. 2.—Coarse, friable sandstone.......................... ....2 to 4 ft.
No. 3.—Magnesian limestone, burned for lime............... . . .2 ft.
No. 4.—Calciferous sandstone, in heavy beds, of various grain and texture, sometimes mottled, quarried for building................30 ft.
No. 5.—Shale, arenaceous and mottled with red....... .... 3 ft.
No. 6.—Calciferous sandstone, used as a cut-stone, for sills and fronts.. 4 ft.
No. 7.—Rough and irregular sandstone...................... ....12 ft.

Total exposure....... ....61 ft.

(No. 7 here is probably the upper portion of the *St. Croix sandstone*. The thickness of the *Lower Magnesian* is at least 230 feet.)

(c.) *Fossils of the Lower Magnesian limestone.*

This great dolomite is comparatively meager in fossil contents. It affords a small number (*three* according to Dr. Shumard) of species of trilobites, and a few of bivalve and univalve molluscs. Of these the most characteristic are *Dikelocephalus*, and other trilobites "allied to the family *Olenidæ*" (Shumard); a handsome little *Lingula*, "of an ovate shape, with fine concentric striæ, not distinguishable from *Lingula Dacotaensis*" (Shumard); also another species of *Lingula* much larger than *L. Dacotaensis*; an unnamed species of *Pleurotomaria* (?), an unknown species of *Orthis Terebratula*. Besides these the most frequent fossil, perhaps, and throughout at least the upper portion of the formation, is a species of *Euomphalus* (*Ophileta?*) which is apparently the same that Dr. Owen has described and named *Straparollus Minnesotensis*.* The observations of the present survey have only disclosed a gasteropod

*On page 484 of Owen's final report, Dr. Shumard describes this fossil as found in F. 1. Yet Dr. Owen in his description [p. 581], and on plate II assigns it to the *Lower Magnesian*. A similar contradiction occurs in the double assignment of *Pleurotomaria muralis*. It is referred from the same locality both to F. 2, and F. 3, so constantly that it cannot be attributed to typographical oversight.

fossil, probably the same *Euomphalus*, in the upper portion of the formation, seen in the bed of the Zumbro, at Rochester, near the Bradley House; and a species of *Lingula* answering the characters of *L. Dacotaensis*, in the same stone where quarried by Messrs. Maxfield and Sons, at Mankato.

In Iowa crinoidal remains are found in the *Lower Magnesian*. In Wisconsin near Madison a *Dikelocephalus* trilobite was found in the drift, supposed to be from the *Lower Magnesian*, and Prof. Hall also reports various indistinct remains of *Orthoceratites*. In western Canada the *Lower Magnesian* exhibits a more abundant fauna, including different genera of trilobites, orthoceratites, gasteropods, and brachiopods. The great "Quebec group" which, in eastern Canada, is supposed to include the *Lower Magnesian* of the Northwest, unfolds an entirely new and wondrously rich assemblage of Silurian fossils.

(d.) *Economical value of the Lower Magnesian.*

The value of this limestone is greatly enhanced by its stratigraphical position. It is not only the lowest in the geological series of the state, but it is separated from the next higher by a considerable thickness of friable sandstone. Therefore it must serve all the uses to which limestone may be put, throughout the area of the granitic and metamorphic rocks,* and also throughout the adjoining belts of the *Potsdam* and the *St. Croix*, and the *St. Peter* sandstones on either side.

As its name indicates, it is not a pure limestone, but a dolomite, or magnesian limestone. It usually contains about one equivalent of carbonate of lime, and one of carbonate of magnesia, with some insoluble silicates, and traces of alumina and iron, the largest per cent. being made up of carbonate of lime. It was formerly believed that a dolomitic limestone was not adapted to lime-burning. The pure limestones, or those that comprise about ninety per cent. of carbonate of lime were eagerly sought for the strength and quickness of the lime they afford. Such is the character of most of the first twenty feet of the *Trenton limestone*, which lies above the *St. Peter sandstone*. It has more recently been found, however, that the magnesian limestones, to which class belong most of those of

*No notice is here taken of *metamorphic limestones*, some of which may occur in Minnesota. They furnish the *marbles* of the New England states.

Upper Silurian age in the Northwest, as well as the *Lower Magnesian* and the *Galena* of the Lower Silurian, afford a quicklime which, although less hot in slacking, and slower in setting, is on the other hand more cheaply burned and better adapted to the uses of common mortar.

"The properties of these limestones are very different. Those of the first class require to be submitted to a higher temperature in 'burning' than the second. They slake promptly and thoroughly and in the operation evolve a great degree of heat. From this last fact they are termed 'hot' or 'fiery' limes. They 'set' or harden so soon that but two or three bricks can be laid with one spreading of mortar, and walls that are made of them have a tendency to 'chip-crack.' It is quite likely that this last named property can be attributed, in some degree, to the silica and alumina that they contain.

The second class contains those limes that are called 'cool.' They do not give out as much heat in slaking as the limes of the first class, nor do they 'set' as soon. From five to twenty bricks can be laid with a single spreading of mortar, and in plastering a corresponding advantage can be obtained.

On purely practical grounds the builders of southwestern Ohio have come to recognize the greater desirability of the limes of the last named class, and none others can now find market in the cities and towns of this portion of the state." [PROF. EDWARD ORTON, on the geology of Montgomery county, in the first report of progress of the geological survey of Ohio, for 1869].

The lime made from the *Lower Magnesian* in Minnesota is, so far as observed, of a very dark color. It is distinguished in some places as "black lime," in comparison with that burned from calcareous tufa, which is called "white lime." In other places it is known as "leather-colored" lime. Yet even where the bulk of the lime produced is of a dark color, some inconsiderable spots and streaks are almost as white as lime made from any other formation.

The lime made at Shakopee, in Scott county, is exceedingly dark, and is commonly known as leather-colored. It has not the purplish or ashen tint of some dark, Ohio limes from the Hamilton limestone, but an ochreous or umber color. It is also specked and sometimes streaked with whitish spots or with shades of lighter brown, and in slacking it takes the color of rich cream.

At the kiln of Mr. Isaac Lincoln, lime sells at 75 cents per barrel of 225 pounds, on the ground. Last year 16,000 barrels were shipped, or an average of 1,300 barrels per month. The monthly production sometimes reaches 2,700 barrels. The markets are mostly St. Paul and Minneapolis. Mr. Lincoln burns from four to five cords of mixed wood to each hundred barrels, and uses a constant kiln of a patent unknown.

The other kiln at Shakopee is owned by Mr. Baptiste Contre. Lime here sells mostly at St. Paul and Minneapolis at 75 cents per barrel. The monthly production is from 1,200 to 1,700 barrels, consuming four or five cords (mostly *four* cords) of mixed wood per hundred barrels. The kiln is similar to that of Mr. Lincoln. At Louisville, four miles further up the Minnesota valley, are two other limekilns employed in burning the *Lower Magnesian.*

At Mankato, in Blue Earth county, the quarry of Messrs. Maxfield and Son supplies both quicklime and building stone. The former is delivered at the depot at 80 cents per barrel of 225 pounds. Twenty cords of mixed wood burn three hundred barrels.

Stone from the quarry of Messrs. Maxfield and Son, at Mankato, has been used in the construction of the Catholic church at that place. The foundation and all dressed stone in the Second Normal School building are from the same quarry. The foundation and dressed stone in the City bank and in Harmonia hall, as well as the entire structure of Higgins hall, and the fronts of several business blocks, at Mankato, are from the same quarry.

At Kasota, in Le Sueur county, the *Lower Magnesian* is considerably wrought, and is finding market at Minneapolis and St. Paul. Quarries here are owned by Reuben Buttárs, J. W. Babcock, and by Downs Brothers. The stone itself is handsomely tinted with pink; and for its beauty, its regularity of bedding which is sometimes nearly two feet in thickness, and its homogeneous texture which renders it easy to shape into all forms, it is adapted to ornamental work as well as heavy masonry. It is cut, as at Mankato, into posts, sills, caps and water-tables. For its adaptability to all uses it is worthy of being ranked with the Waverly sandstone, and it is more enduring even than that, under the action of atmospheric changes, owing to the more general and abundant dissemination of the calcareous cement; while its variegated coloring, and its more lively expression make it preferable in many kinds of work. It is used in the north and south wings of the state lunatic

asylum at St. Peter, and the central portion of the building, when completed, will contain it. The Episcopal church, and the old Asylum building are also constructed from it. The new Baptist church at St. Paul is being made from the Kasota stone. In old structures where it has been exposed for a number of years to the disintegrating action of the elements, it shows as sound and hard as ever. It even becomes harder on exposure, as the quarry water dries out.

At St. Peter, in Nicollet county, a quarry owned by the Asylum farm affords a stone of a lighter color, but otherwise very similar to that from Kasota, being also in the *Lower Magnesian.*

At Red Wing, in Goodhue county, the quarries near the top of La Grange, or "barn bluff," supplied from the *Lower Magnesian* the stone put in the railroad-bridge over the Mississippi at Hastings, and also that used in the Episcopal church at Red Wing.

At Winona, in Winona county, valuable quarries in this formation have been opened in the "sugar loaf," by Mr. Toms, and in the bluff next west of "sugar loaf" by Mr. James Burke. These quarries supplied the trimmings and all cut-stone used in the normal school at that place.

At Stillwater, in Washington county, the *Lower Magnesian* is extensively used for the most important structures. Some of it is quite close-grained, and without pores, making a fine cut-stone of a light cream-color. Some of it, from the same quarry, is also very rough and porous, and of a darker color. That, however, which is rough and porous is as enduring as that which is compact. Indeed the porous masses are apt to be more lasting and in heavier beds than the close-grained. This stone has been put into the public school-house at Stillwater, and as trimmings in many houses built of brick. The state prison at the same place is built of it. The court house is of red brick (made near Stillwater), the trimmings being of the *Lower Magnesian* quarried at Stillwater, and of the blue flagging, from the *Trenton* quarried at St. Paul. The steps in front and the walls at the ends of the steps are of the *Lower Magnesian*, while the coping, sills, lintels and water-tables are of the darker colored *Trenton*. Several churches at Stillwater are made of the *Lower Magnesian* with *Trenton* blue flags from St. Paul, for sills, caps and water-tables. This combination of colors gives the structure a very attractive *ensemble*, but it is at the cost of durability. It is a great mistake to place these blue flags in

such exposed parts of important buildings. They are much more destructible than the *Lower Magnesian*, and will fall out in chips and thin shaly partings long before the weather has any effect on the *Lower Magnesian* of the main walls.

4. THE ST. PETER SANDSTONE.

(a.) *Its area.*

The incoherency of this sandstone renders a definition of its area very difficult. It is placed between two important limestones of the Lower Silurian, both of which endure the erosion of ice and water and the disintegrating action of atmospheric forces with greater persistence than the sandstone itself. The underlying *Lower Magnesian* is apt, in the southeastern portion of the state, to stretch out for several miles over a low flat, its upper surface forming the basis. But as it gradually passes, owing to a gentle dip, below the surface, occasional isolated mounds rising about 125 feet above the general level are seen by the traveler. These become more and more frequent and at last coalesce in the direction of the dip, so as to form a continuous flat topped shoulder or bench, like the *mesas* of New Mexico, on which the same features of surface and soil prevail as on the lower flat formed by the *Lower Magnesian*. On examination of these precipitous ascents from the lower to the higher prairie, they are found to consist of the *St. Peter sandstone*, capped with the first fifteen or twenty feet of the overlying *Trenton limestone*. As this protecting limestone has a thickness of about 160 feet it also furnishes a further ascent, but one that is not marked off by so distinct bench-lines. Owing to the occurrence of considerable shale and easily erosible beds at about the horizon of twenty feet above the *St. Peter sandstone*, it happens that often over a wide belt only these twenty feet of the *Trenton limestone* are preserved. They form the brow of the hill that separates the lower from the upper prairie, already mentioned, and have hitherto been more fully examined than any other portion of the *Trenton* within the limits of Minnesota. Hence the area of the *St. Peter sandstone* is actually reduced, where the boundaries of the formations are easily seen, to the narrow belt forming the slopes between the upper and lower prairies. These slopes are generally turf-covered. The delineation of the area of the *St. Peter* is further complicated by the action of streams. These often cut

their channels through the overlying twenty feet of *Trenton*, and into the *St. Peter* some miles above their debouchure on the actual area of the *St. Peter;* and near their entrance upon the area of that sandstone their channels are widened out enormously, the enclosing bluffs receding rapidly from the immediate river banks. In addition to these irregularities of outline, there are not infrequently detached areas within the general limit of the *Trenton limestone* where the protecting beds of the Trenton are broken down and removed by some force not now in operation, forming, in the *St. Peter*, basin-shaped depressions, the bottoms of which are on the *Lower Magnesian*, the surrounding bluffs being made up of the *St. Peter sandstone*, and the high prairie stretching out in all directions being underlain by the Trenton. Such *arroya* valleys, which are now without any visible surface drainage, are sometimes united by wide mouths with other, larger valleys that present a similar topography. Indeed the whole belt of country underlain by the outrunning *Trenton* and the *St. Peter sandstone* is made up of a network of little valleys many of which coalesce and become tributaries to larger drainage valleys, and some of which appear simply as isolated depressions. It is a tract of rolling country of great beauty of natural scenery, and most perfectly exemplifies the effect of geological causes on the topography and agricultural character of the state.

This belt of rolling land immediately dependent on the underlying rock enters the state from Iowa in Houston county, in a general northwesterly direction. It embraces the western portions of Houston and Winona, the eastern portions of Fillmore and Olmsted, and some portions of Wabasha, Goodhue and Dakota counties. Further northwest, in the counties of Ramsey, Hennepin and Anoka, the area of the *St. Peter sandstone* is heavily covered by drift, and its presence would not be known except for its exposures in the Mississippi bluffs, and the known limits of adjoining formations. From Dakota county the *St. Peter sandstone* extends theoretically southwestwardly in a belt of 6 to 10 miles wide, passing through the central part of Rice county, touching the northwest corners of Waseca and Faribault, and leaving the state again in Martin county in a southwesterly direction. On the other side of the granitoid axis, in the northwestern portion of the state, a belt of this sandstone is supposed to exist, and is conjecturally laid off on the preliminary map accompany this report.

(b.) *Lithological characters of the St. Peter sandstone.*

The outward, and also the chemical characters of this sandstone, in Minnesota, are, so far as seen, remarkably constant and simple. It is white, "saccharoidal," friable, non-fossiliferous, and consists almost entirely of pure quartz sand. It contains not enough lime to act as cement, and hence can almost everywhere be excavated even with the fingers. On exposed surfaces, as along the bluffs of the Mississippi, where dripping water passes over it, the grains become more bound together by deposition of carbonate of lime and iron oxide, and its delicate whiteness is lost. Indeed, wherever water in the smallest quantity is allowed to trickle through it, a deposit of iron oxide is invariably seen, since rarely, if ever, is any surface water found entirely free from that impurity.

A number of sections have been observed of this formation, but the characters seem to be invariable throughout. Its thickness is about 125 feet, and it is the immediate cause of a great many waterfalls. The falls of St. Anthony are caused by the passage of the river from the *Trenton limestone* onto the *St. Peter*. The latter, rapidly worn away by the current, leaves the projecting limestone to fall down in heavy blocks as fast as it becomes too feeble to support further its own weight. This protecting cap of limestone extends but a few rods above the present brink of the falls, and it was a thoughtless tunneling underneath, in the soft *St. Peter*, that admitted the water of the Mississippi a few years since, above the limit of the limestone, thus endangering the existence of the falls themselves. They would soon have been reduced to a foaming rapid, which eventually would have entirely disappeared. Vigorous measures were speedily adopted by the citizens of Minneapolis, tardily aided by the U. S. government, to secure the water-power, and by carefully shutting off the water from the tunnel, and "aproning" the waterfall itself with heavy timbers and planking, as well as laying over the river bottom above the falls a thickness of gravel and clay to prevent a further erosion, it is believed that desirable object has been effectually secured. The falls of Minnehaha are also caused by the same conjunction of a drainage stream with the boundary line separating the *St. Peter* from the *Trenton limestone*. This unique and legendary little gem of a waterfall has a perpendicular descent of 52 ft. 10½ inches from the brink of the

overhanging limestone to the surface of still water below. About twenty-five feet of that distance are taken up with the *St. Peter sandstone.* Numerous little cascades of great beauty enter. the Mississippi in the vicinity of St. Paul and Minneapolis. As these are projected over the limestone rim which borders the Mississippi bluffs, they are thrown in more or less entire sheets of clear water into the river below. Such are known as *the fawn's leap, the bridal veil, the silver cascade* and *the silver thread.*

The singular pillar in Dakota county, known as *Castle Rock,* consists of the *St. Peter sandstone.* It stands on the arch of the local anticlinal axis from which the beds dip gently both toward the north and toward the south, and is an outlier from which most of the formation has been removed over an area of some miles about. Its form is that of a somewhat regular right prism, or parallelopipedon, elongated north and south, supporting on its northern end a pinnacle of bedded sandstone about four feet in diameter at the base, which rises above the general mass 19 ft. and 3 inches. A view from the west shows of rock 44 feet and 9 inches, rising above the general surface of the sandy mound on which it stands. Rock can be seen on the east side about 20 feet lower than on the west. A depression along the east side of the outlier is 26 feet below the lowest rock visible. From the bottom of this depression to the top of the tower is 70 feet 1¾ inches. The irregularly ascending base visible from the west is 11 ft. 6 in. The perpendicular sides of the general mass of the rock are 14 ft., and the tower is 19 ft. 3 in. Near the base of the tower is a somewhat argillaceous layer, or one less firmly cemented, of a few inches, which weathers away faster than the rest, making the diameter there considerably less than above. Hence the tower has a threatening aspect, and the first impression of the beholder is the certainty that the first severe blast of wind will throw it from its place. The mass of the whole is separated perpendicularly by a number of divisional planes that also may be seen entering the rock below the castle. These pass in a direction N. E. and S. W. and have so aided the attacks of the elements and invited the ambitious but sacrilegious carvings of visitors that a hole has been made through the body of the rock.

(c.) *Economical value of the St. Peter sandstone.*

The St. Peter furnishes inexhaustible quantities of the purest

quartz sand. Its easy excavation renders it obtainable for common mortar and for glass-making. Its exposures along the Mississippi bluffs at and below St. Paul invite its use in the manufacture of flint glass of which it is known to make a very superior article. At Minneapolis the close proximity of waste fuel from the lumber mills, ample water-power and favorable exposures of this formation ought long ago to have been improved in the establishment of a glass manufactory. At the present time Minnesota furnishes from the *St. Croix sandstone* a sand believed to be inferior to that from the *St. Peter*, which, taken to a neighboring state, supplies the glass that returns to her citizens encumbered with a double freightage. This process ought to be arrested by the utilization within our own territory of this vast resource, peculiar largely to Minnesota. At present this sandstone is not known to be used for any purpose within the state except for mortar for the local markets and as an engraving board for idle boys. Sometimes beer vaults are made in it along the river bluffs, and sewers for the drainage of the cities of St. Paul and Minneapolis are excavated through it, the overlying limestone affording a secure roof.

5. THE TRENTON LIMESTONE.

(a.) *Preliminary considerations.*

This term is here applied to that series of limestones and shales that fill up the interval between the well marked horizons of the top of the *St. Peter sandstone*, and the bottom of the *Galena limestone*. It is quite likely that when this series of beds is fully examined differences may be ascertained warranting its separation under two or more names, but at the present time the characters of its whole thickness, which amounts to nearly 160 feet, are so little known that it has not been possible to establish any constant paleontological or lithological horizons. Dr. Owen, in his final report on Wisconsin, Iowa and Minnesota, mentions only the lowest 34 feet of these limestones, owing to the more frequent exposure, as has been mentioned already, of that portion of the *Trenton*. Those 34 feet Dr. B. F. Shumard separates into the following parts:

1. Upper, or St. Peter shell limestone, F. 3. c.................6 feet.
2. Non-fossiliferous bed, F. 3. b..............................5 feet.
3. Lower shell limestone, F. 3. a..............................23 feet.

The geologists of Wisconsin have described these limestones under the terms "buff limestone" and "blue limestone," the former lying below the latter, following the preliminary sub-division of Dr. Owen, published in a report of progress in 1840. They there have a thickness of 70 to 90 feet.* These distinctions have not yet been observed in Minnesota, and the aggregate thickness of the beds is considerably greater. The early geologists of Iowa gave the term *Trenton limestone* to all the layers between the *St. Peter* and the *Galena* and assign them an aggregate thickness of 100 feet.† Dr. C. A. White, also, of the recent geological survey of Iowa, embraces these shales and limestones under the single term *Trenton limestone*, but ascertains their thickness to be about 200 feet.‡ Mr. Worthen, in Illinois, embraces the *Galena*, the *Blue* and the *Buff* limestones under the term of *Trenton Group*, giving the latter two a united thickness of 70 to 105 feet, the *Galena* overlying, having a thickness of 250 to 300 feet.§

(b.) *Area of the Trenton limestone.*

The *Trenton* occupies a belt of country lying just within that of the *St. Peter*, in the southern part of the state, and conjecturally an area in the northwestern part of the state. The former may be described with considerable exactness. By reference to the description of the area of the *St. Peter* it will be seen that the line separating these two formations is very crooked, especially in the southeastern portion of the state, where the drift is light. The causes that operated to give this line such a winding direction, up and down hundreds of little valleys, seem to have pertained largely to pre-glacial time, and to have continued also into, and near the close of, the ice period,—or to have recurred, after a suspension, during the ice period with all their former activity. They seem to have been closely connected, perhaps identical, with those that exempted this region from the heavy covering of drift that prevails further west and north. At least, it is plain that the absence of the drift has allowed the freer action of the elements that slowly, but effectually disintegrate and remove rocky structures, causing those which are most enduring to stand out most prominently, af-

*Geological survey of Wisconsin, 1861, vol. I.
†Geology of Iowa, 1858, vol. I. part I.
‡Geology of Iowa, 1870, vol. I.
§Geological survey of Illinois, vol. I.

fording shelter to those which retreat fastest from their attacks.

The western line of the *St. Peter* is the eastern line of the *Trenton*, in the southeastern portion of the state, and need not be further defined. The western line of the *Trenton*, in the same region, although less tortuous than the eastern, is still quite irregular, the overlying *Galena* comparing, in respect to relative endurance, to the *Trenton*, very much as the *Trenton* does to the *St. Peter*. It is impossible definitely to lay out this area until the various counties are examined in detail, but in general the area of the *Trenton* comprises a wide belt through the central portions of Fillmore, Olmsted and Goodhue counties, including three or four towns in the southwestern corner of Winona, and touching the southwest corner of Wabasha. This belt is then deflected westward through the counties of Rice, Blue Earth and Faribault, leaving the state probably in Martin county. Isolated areas occur in Dakota county, capping the *St. Peter sandstone*; and a large detached area of the lower portion of the *Trenton*, with a local dip toward the north, covers the northern portion of Dakota and much of Ramsey and Hennepin counties. This detached area gives location to the falls of St. Anthony. The area of *Trenton* in the northwestern portion of the state is laid off conjecturally, the only guide being the report of Prof. H. Y. Hind on the Assiniboine and Saskatchewan districts of British America, printed in 1859.

(c.) *Lithological characters of the Trenton limestone.*

In Minnesota, as far as seen, the *Trenton limestone* is abundantly associated with beds and laminations of green shale. The calcareous layers themselves are usually from one to four inches in thickness, but sometimes exceed a foot, while the beds of shale are apt to be massive and sometimes have a thickness of ten feet. The shale beds are often supplied with fragmentary fossils, and the layers of limestone are uniformly fossiliferous. The calcareous and argillaceous portions are also in some portions of the formation more closely interstratified; or the shale may be interwoven with the calcareous layers in such a way as to replace them at short intervals, the whole adhering strongly on fresh fracture, but on being weathered readily disintegrating. This is the aspect of some of the beds near the bottom of the formation which are used for building purposes at St. Paul and Minneapolis. The stone in this

ase has an attractive exterior on being dressed under the hammer, he variegations due to the alternating shaly and limy parts giving he face a clouded appearance, as of gray marble, without being susceptible of a uniform polish. Where protected from the weather the shale will endure, and act as a strong filling for the framework of calcareous matter for a long time; but under the vicissitudes of moisture and dryness and of freezing and thawing, it begins to crumble out in a few years. In other places the calcareous layers, even on the same horizon as at Minneapolis and St. Paul, are very much thicker and afford strong unyielding material for building. In this last case the calcareous layers are more strongly crystal- ine, but not vesicular. Many of them, especially when associated with considerable shale, are nearly made up of fragments of fossils, isible to the unaided eye, and doubtless the shale beds are also alcareous as well as sedimentary. The texture of the stone is lose; yet some portions near the base, thought to be the beds de- ominated by Dr. Shumard "upper shell limestone," are often esicular and of a light color. The natural color of the stone, on leep quarrying, is blue, but it is often faded to an ashen drab to he depth of several feet, depending on the ease with which water and air find access within. The porous layers are apt to be most aded. The long weathered surface is of a light buff color, or if iron be present in dripping water, or contained in the stone as pyrites so situated as to be oxidized, the color is sensibly deepened to a rusty yellow.

The effect of this formation on the topography of several counties in the southeastern portion of the state has been alluded to in connection with the same subject in treating of the *St. Peter sandstone.* Owing to the frequency of shaly interlaminations its outline, where the drift is light, is not so well defined in terraces as that of the overlying *Galena.* Its line of junction with the *St. Peter sandstone* is, indeed, very evident even in all its tortuosities, but its junction with the *Galena* is generally hid by a sloping, turf-covered talus of *debris*; and it is only at favorable places in the bluffs along the streams that a knowledge of that horizon can be obtained. The whole formation weathers away so evenly that where its effect on the topography is not brought out by drainage erosion or by the *Galena limestone* or the *St. Peter sandstone*, it produces nothing more than a gentle swell or evenly rounded ridge exposing none of the beds.

Sections have been observed covering all the beds of the *Trenton*

The best section of the *lower* and *upper shell beds*, of Dr. Shumard, is that taken at the falls of Minnehaha, although the same beds are seen well exposed at many places between St. Anthony's falls and St. Paul.

Section at the falls of Minnehaha, Hennepin county.

In descending order.

No. 1.—Beds 6 to 14 inches, very fossiliferous and sometimes vesicular. Contain *Leptæna deltoidea* in abundance, and *Strophmena alternata (?)*, also a *Cypricardites*. This is an important and marked horizon to which other sections may be referred. It forms the brink of the falls, but its best exposure is in a bluff a few rods below. Seen	9 ft.
No. 2.—Argillaceous limestone of a greenish color, weathering out conchoidally	2 ft.
No. 3—Arenaceous shale, weathering fine	2 ft.
No. 4.—Blue flagging, with considerable green shale. The principal building stone of Minneapolis and St. Paul is from this member. Great portions of this are made up solely of comminuted fossil remains showing crinoidal joints. It is of sedimentary rather than of chemical origin	13 ft. 6 in.
No. 5.—Green shale, about midway containing one layer of about two inches of limestone	3 ft. 8 in.
No. 6.—*St. Peter sandstone*, somewhat argillaceous, and of a greenish blue color	2 ft.
No. 7.—*St. Peter sandstone*, superficially stained and hardened by lime and iron	25 ft.
Total	57 ft. 2
Total of the *Trenton*	30 ft. 2 in

Section near the falls of St. Anthony, Hennepin county.

A quarter of a mile below the university. In descending order.

No. 1.—Limestone, mostly of a close grain and bright blue color, showing many fossils, principally of *Leptæna deltoidea*, but also containing cephalopods and gasteropods. The fossil remains are usually not fragmentary. They are apt to lie in sheets, making dark streaks horizontally separating the bedding. Under the weather this stone falls out in chips ½ to 2 inches thick and 4 to 8 inches across, which ring under a blow from the hammer. The surface weathers a rusty buff, the stone itself becoming a gray drab	11 ft.
No. 2.—Blue shale, crumbling out, the upper four feet somewhat bedded, the rest below massive, the whole occasionally showing patches or short sheets of fragments of brachiopods, &c., making the rock more calcareous and enduring	9 ft.
No. 3.—Blue flagging, quarried here and placed in the west wing of the university building. This stone is rather too argillaceous to be a reliable building material, yet is extensively used. Some parts of it are free from shale. Such beds furnish a firm and very enduring stone	15

No. 4.—Blue shale, parting conchoidally under the weather, seen....... 2 ft.
[No. 5.—St. Peter sandstone, to the water level 38 ft.]

Total of the *Trenton*........... .... 37 ft.

The total hight from the water's edge, at this quarry, to the summit of the drift bluff on which the university stands, measured by Locke's level, is 137 feet.

There is no visible dip here in the bedding, but at the falls of St. Anthony the dip is two or three degrees to the southeast.

At the point where the foregoing section was taken the *St. Peter sandstone* is tunneled artificially to the depth of nearly 200 feet, the excavation being ten or twelve feet in diameter, rudely dug out and arched. It was intended for a beer-vault.

Section at St. Charles, in Winona county.

At a quarry near St. Charles, half a mile south of the city, the lower portion of the *Trenton* appears as follows, in descending order:

No. 1.—Hard, crystalline, calcareous layers, ringing under the hammer, of a light drab color, without shale, fossiliferous.......... .... 15 ft.
No. 2.—Bluish green shale, about.................................. 10 ft.
[No. 3.—*St. Peter sandstone*, seen 6 feet.]

Total *Trenton*..................... .... 25 ft.

At this place the dip is two or three degrees S. W. St. Charles sits on the top of the *Lower Magnesian limestone*, which is seen in a quarry a little N. E. of the city, and is nearly surrounded by bluffs formed by the *St. Peter sandstone*, capped with the lower portion of the *Trenton*. This exposure of the *Lower Magnesian* is along a little creek, the amount of bedding seen being about 16 feet.

Sections at Rochester, in Olmsted county.

At the "old Harmon quarry," from which the flouring-mill and the foundations for the new public-school house were built, the lower portion of the *Trenton* appears as follows, in descending order:

No. 1.—Green shale, seen... .... 4 ft.
[This is said by Mr. Hurlbut to be about 14 feet thick where it is all preserved.]
No. 2.—Hard, brittle limestone, in two beds, separated by about two inches of green shale. This is much like No. 1, of the foregoing

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section at St. Charles. It has a drab color. A handsome *Strophomena* is the most characteristic fossil....................... 1 ft.
No. 3.—Alternations of shale and limestone....................... 1 ft.
No. 4.—Limestone of the same kind as No. 2, with some partings of shale, but sometimes quite blue instead of drab, seen...........10 ft.
No. 5.—Blue shaly limestone, more like the blue flagging quarried at Minneapolis. Not well exposed; amounts to about............ 6 in.

Total *Trenton* seen ....16 ft. 6 in.

At another point further west, on Mr. O. P. Whitcomb's land, the bed of green shale separating the foregoing *Trenton* from the *St. Peter sandstone*, or rather forming the base of the *Trenton*, may be seen in a weathered bluff, exposing a thickness of about ten feet, as at St. Charles. The quarry of Mr. O. P. Whitcomb, at Rochester, is made up as follows, in descending order:

No. 1.—Green shale, containing fragmentary crinoidal stems, *Chætetes* and various small brachiopods, among which may be distinguished a *Rhynchonella*. [Mr. Hurlbut thinks about 5 feet more are broken down from above, not now visible.] seen .... 10 ft.
No. 2.—Limestone, of a drab color and fine grain, in beds of about three inches, with much intervening shale in continuous layers.......... 3 ft.
No. 3.—Compact limestone, used in building, of a blue color, but comparatively free from shale....................................... 17 ft.
No. 4.—Green shale, lying on the *St. Peter sandstone*, not well exposed, seen... 1 ft.

Total *Trenton* seen.. 32 ft.

From No. 2, above, have come some of the finest and largest specimens of cephalopods.

Section on Root river, in sec. 16, Pleasant Grove, Olmsted county.

At the point observed the section consists, in general, as follows, in descending order: Perpendicular escarpment showing generally a thin bedded and often shaly rock, the thin shale partitions being as thick as ½ or 1½ inches, about 37 feet. The descent then is irregular over beds of argillaceous limestone and shale mostly hid from view. Some of these shale beds are six and eight inches thick, and from them, where crumbling under the weather, fragments of fossils fall, such as *Chœtetes* (principally), *Maclurea* and *Orthis*. The limestone weathers rough and thin-bedded, and shows *Receptaculites*. This interval includes about 47½ feet. There is then a broad shoulder, making up a talus covering, as disclosed,

further down the river, a heavy bed of green shale, which overlies, near the water's edge, the limestone layers of the foregoing sections at Rochester, 42 feet. Total of beds supposed to be of the *Trenton*, 126½ feet. Combining this section with the observed thickness at Rochester, omitting the overlying shale bed (here embraced in a talus) the observed thickness of rocks of *Trenton* age amounts to 156½ feet against the 34 feet observed by Dr. Owen.

Sections at Mantorville, in Dodge county.

The Mantorville quarries show the horizon of the junction of the *Trenton* with overlying *Galena.* The same horizon is better exposed at Pettit's mill, one and a half miles below Mantorville, on sec. 22, T. 107, R. 16, along the middle branch of the Zumbro river. These sections are as follows:

1st. That of the quarry of Mr. Charles Ginsberg, in descending order:

No. 1.—[Loose fragments, 5 ft.]	
No. 2.—Heavy beds of vesicular, magnesian buff limestone........	8 ft.
No. 3.—Thin beds of the same, with a little shale................	4 ft.
No 4.—Heavy, buff, magnesian beds....	7 ft.
No. 5.—Thin, blue argillo-magnesian beds.......	10 ft.
No. 6.—Even-bedded magnesian limestone, the bedding of which weathers out from two to six inches, (poorly seen).......	5 ft.
Total seen...............	34 ft.

At this quarry the buff or cream colored stone shows a light blue color in deep quarrying.

2d. The quarry of Mr. Samuel Wilson, located near Mr. Ginsberg's, includes more of the *Galena.*

No. 1.—[Loose fragments, 4 ft.]	
No. 2.—Beds from six to twenty inches each, of vesicular, magnesian limestone, almost free from iron, fine for a "quarry stone"........................	30 ft. 10 in.
No. 3.—Thin, slaty, argillo-magnesian beds....................	1 ft. 6 in.
No. 4.—Good, heavy beds of magnesian limestone, same as No. 1.	11 ft. 6 in.
No. 5.—Shaly and thinner beds, seen.......	5 ft.
[NOTE.—Where these beds are weathered out, a white deposit is accumulated on the slope below, having much the taste of lime, yet may consist of alumina and lime. On the face of the rocks the coating is bitter and sour, tasting somewhat like Epsom salt.]	
No. 6.—Heavy magnesian layers, of a buff color, with considerable shale, same as Nos. 3, 4 and 5, of Ginsberg's quarry, but poorly seen, about	20 ft.
Total seen...	68 ft. 10 in.

The Episcopal church and chapel and the school building belonging to the same society at Faribault, as well as the public school houses of the city, and some large business blocks are laid up with this limestone.

The "Faribault marble" is a bed in the same quarries, lying between common building-stone layers, and having a thickness of something less than a foot. It is susceptible of a fine polish, and has a gray color. It is made into table and stand trimmings which show various markings and mottlings, owing to the contained fossils and the various lithology of the stone.

6. THE GALENA LIMESTONE.

(a.) *Its area.*

The line of junction of the *Galena* with the *Trenton* is pretty well marked in the southeastern portion of the state through the counties of Fillmore and Olmsted, but its junction with the *Maquoketa shales* has not yet been observed at a single place. Hence the width of the *Galena* belt is unknown, although it does not probably exceed ten miles. In the southwestern portion of Goodhue county the *Galena* is deflected toward the west, and finally in Rice and Waseca counties toward the southwest, passing through Faribault and leaving the state in Martin.

(b.) *Its lithological characters.*

This limestone was included by Dr. Owen in his designation "Upper Magnesian limestone," that term also covering the *Niagara limestone* which is separated from the *Galena* by a thickness, unobserved by Dr. Owen, of about 75 feet of shales named by Dr. C. A. White of Iowa the *Maquoketa shales*. It was, however, distinguished by Dr. Owen under the special designation of "lead-bearing beds of the Upper Magnesian." Lithologically it has a great similarity to the *Niagara*. Its usual color is buff, although on deep and fresh quarrying it also shows that its normal color, like most other limestones, is blue. Its composition, like that of the *Lower Magnesian*, is dolomitic, comprising a large percentage of carbonate of magnesia. Its texture is open, even porous, with minute cavities. It also exhibits large cavernous patches, with a rough and forbidding aspect. These, however, are not common, the sedimentation having been generally so undisturbed by chem-

ical or mechanical agencies that the layers are yet well preserved. The grain is crystalline, and sometimes granular. Minute crystals of brown spar often line the cavities. It also sometimes embraces iron pyrites which, weathering out, stains the face of the rock with a rust of iron. It probably also embraces galena in some parts of its area in Minnesota, although this mineral has not actually been found contained in the rock. Pieces of considerable size are found by the farmers in Olmsted county in plowing near the bluffs of this formation, which have apparently fallen down on being loosened by the weather, the drift there being comparatively light. The lower beds of the *Galena* are interstratified with the *Trenton.* This may be seen by comparing the sections covering that horizon at Mantorville and at Pettit's mill. (See pages 99 and 100.) A thickness of about 20 feet is taken up by alternating shale and limestone, the latter gradually losing its distinctly dolomitic characters and passing into the grayish and blue compacter beds of the *Trenton.*

In the southeastern portion of the state, where the *Galena*, owing to the thinness of the drift deposit, is seen in the bluffs and terraces with which the face of the country is diversified, its irregular outline is easily traceable for many miles. It forms the summit of a distinct terrace of which the underlying *Trenton* shales and limestones constitute the foundation, and from the top of which the overlying *Maquokèta shales* seem to have been denuded. It thus shows its more persistent character more distinctly than if it lay between formations of equal hardness. Its thickness is estimated at 180 feet.

The lithological character of the *Galena* is also frequently evident in the form of precipitous escarpments, and prominent, often detached, crags along the valleys of streams, where their channels are deeply cut. The point lying between two valleys which unite is sometimes wrought by the combined action of water and air into picturesque or fantastic shapes, the beauty and grotesqueness of which is hightened by the seclusion of the place. These unevenly weathered surfaces are due to variations in the hardness and durability of the texture of the *Galena.*

Some of the observed sections in the lower portions of the *Galena* have already been given under the head of the *Trenton limestone.* Those at Mantorville and Pettit's mill expose upward of 40 feet of this formation, and need not be repeated here. The beds exposed in Mr. Thomas Garrick's quarry, on sec. 18, in Rochester, Olmsted

county, show about 25 feet of a very uniform and evenly bedded stone, of a buff or light cream-color, and crystalline, often granular texture, in which are many cavities from which the fossils have been absorbed, besides often a minutely vesicular and open structure.

(c.) *Fossils of the Galena limestone.*

Wherever the *Galena* has been examined in Minnesota, the most striking, and perhaps the commonest fossil is the sunflower coral, *Receptaculites.* Examination sufficiently detailed has not yet been made to establish the species to which specimens collected may belong. There can be but little doubt, however, that the usual species at Dubuque (*Oweni*. Hall) is also the most common in southern Minnesota. *Orthoceratites,* sometimes of large dimensions, are also common in the *Galena*, especially near the base. Species of *Murchisonia*, and apparently of *Pleurotomaria* have also been seen. Of brachiopods various species that appear like *Orthis* and like *Strophomena*, in addition to *Lingula quadrata* (Eichwald,) have been collected from the outcrops of the *Galena*. The paleontology of the *Galena* is studied under unfavorable circumstances arising from the crystalline condition of the rock, which has generally caused the absorption of the shelly portion of the animal, leaving only its shape entombed in the form of a cast. In other cases the fossils are so nearly obliterated by this means that the casts themselves are chemically united with the mass of the rock, rendering their separation impossible.

(d.) *Economical value of the Galena limestone.*

This limestone derives not only its name but its special interest to the geologist and great economical value to the states further south, from the occurrence in it of workable and valuable deposits of the sulphurets of lead and zinc, called galena and blende. These deposits specially prevail in that district denominated by Prof. J. D. Whitney "the driftless region," in the states of Iowa, Wisconsin and Illinois. This driftless tract spreads much further northwestward, covering much of the southeastern portion of Minnesota. Fully admitting Prof. Whitney's theory as to the non-submergence of this region since the deposition of the Silurian limestone, there are many facts which will not permit such non-submergence to

explain the apparent absence of the northern drift in that part of the Northwest, chief among which is the absence of proof that any portion of the drift of the Northwest is due to general submergence below the waters of the ocean. The fact of the thinness of the drift in southeastern Minnesota has been referred to under the head of *surface geology*. The features of surface that prevail throughout this district are the same as those seen about Dubuque, in Iowa, and generally throughout the "lead region of the upper Mississippi." The characters of the *Galena limestone* in Minnesota are essentially those of the same limestone in the lead district. The evidence is therefore presumptive of the existence of galena in workable quantities in the northern extension of this formation in Minnesota; at least no cause is known for the limitation of the lead-bearing area to the district in which it is chiefly developed. If the origin of the sulphurets that fill the cavities in the *Galena* be due to the infiltration of those minerals from oceanic waters holding the sulphates of the same metals in solution at the time of the formation of that dolomite, there is no known reason why the *Galena* will not embrace the same sulphurets throughout its extent, at least wherever the causes that produced the precipitation were in force. The cause of that chemical change, assigned by Mr. Whitney, is the decomposition of vegetable and animal remains in the underlying "bituminous" shales of the *Trenton*, a process which, evolving sulphur in the form of sulphuretted hydrogen, would necessarily convert the sulphates in the waters through which it rose, into the corresponding sulphurets. The precipitates gathered in such shrinkage cracks or other cavities as were favorable for its accumulation. These conditions all prevailed, so far as can be learned from the appearance of the rocks themselves, in southern Minnesota equally with southern Wisconsin. When in connection with these theoretical considerations it be remembered that occasional cuboidal pieces of galena are found in the soil in that part of the state where this dolomite occupies the surface, it may be regarded as quite probable that the lead-bearing area extends also into the state of Minnesota, and that by careful and systematic exploration it may be found in the rock itself in paying quantities.

For lime the *Galena* is not much used in Minnesota. Yet it will make a lime of superior excellence. It will burn easily and cheaply owing both to its vesicular texture and the presence of magnesia in the form of a carbonate. It will make a lime of con-

siderable body, but less quickness in slacking and setting than that from the *Trenton*. In that respect it would resemble the quicklime from the *Lower Magnesian*, but it would be whiter, and freer from siliceous matter. The granular texture seen in some parts of the *Galena*, a character common to most magnesian limestones, has sometimes made it pass for a sandstone, and for that reason, although used for a building material, it has not generally been tested for quicklime. Lime for the local markets of southern Minnesota ought all to be supplied from this formation. It furnishes in many of its exposures, along the valleys of streams, the best of opportunities for quarrying.

When in connection with its fitness for quicklime, its merits as a building stone are considered, it is made a little surprising that no more working in this formation has been done. It not only furnishes a building material suitable for all ordinary uses in foundations and abutments for bridges, but it also cuts easily to a regular and smooth surface. Its bedding is sometimes heavy, reaching two or three feet in thickness, and the stone is strong enough to endure both pressure and long weathering. It is of a light and lively color, and in that respect has the advantage of darker colored stone. The quarries at Mantorville, owned by Messrs. Wilson and Ginsberg, have furnished a large amount of good building stone which has been hauled many miles over the country in various directions, past many inviting outcrops of the same formation. It is owing to the investigations of an amateur geologist,* that the existence of this stone in many other places has been made known to the citizens of Olmsted county. Through his recommendations it has recently been opened near the city of Rochester, and is found to supply a stone equal in all respects to that taken out at Mantorville. The quarry of Mr. Thomas Garrick, on section eighteen in the township of Rochester, Olmsted county, exposes twenty or twenty-five feet of evenly bedded *Galena*, useful for general building. At Rochester, Cook's block, the court house, the public school-house and Heaney's block are all faced and trimmed with the *Galena*, hauled from Mantorville. At Mantorville the court house and the school-house are entirely built of it; the former, however, showing several large iron stains in the front walls.

*Mr. W. D. Hurlbut, of Rochester, Minn.

7. UPPER SILURIAN AND DEVONIAN.

The formations that have thus far been described are all included below the Upper Silurian. The *Maquoketa shales* of Iowa, which overlie the *Galena* are also embraced in the Lower Silurian. The *Galena*, however is the highest member of the Silurian that has yet been identified in the state. It is expected that when more detailed exploration shall have been made, the remainder of the Lower Silurian, the upper Silurian and the lower portions of the Devonian will be found to occupy a considerable area in the southern portion of the state. The areas assigned to these rocks in the preliminary map accompanying this report are hence based on the known trend of other formations, and on the maps of the neighboring state of Iowa, which show the Upper Silurian and Devonian as leaving that state and entering this. The same is true of the areas given these rocks in the northwestern portion of the state, the geological map by Prof. H. Y. Hind, of the Winnipeg district, representing the Devonian and Upper Silurian as entering Minnesota from the north.

8. THE CRETACEOUS.

(a.) *Preliminary considerations.*

The geological frame-work of the state having been completed by the deposition of the foregoing Silurian (and Devonian?) rocks, it remained above the oceanic waters during the whole of the Carboniferous and a greater part of the Mesozoic ages, during which it underwent only the vicissitudes of atmospheric changes, till the period of the *Cretaceous*. Large portions of the American continent which are now dry land were yet under the waters of the ocean. At the ushering in of the *Cretaceous* a further submergence brought the *Cretaceous* seas over not only the old Devonian and Silurian dry land, but also in the states of Minnesota and Iowa* over large areas of the azoic and granitic rocks. How much of the state of Minnesota was thus submerged has not yet been ascertained.

If points of elevation only be considered, since it is found in some of the most elevated parts of the southern portion of the state, the entire state must have been submerged. It is possible the surface of the country sank below the ocean unequally, in different

*Compare *Geology of Iowa*, 1870, Vol. I, p. 168.

localities, and also that it rose with similar irregularity. Hence points that now show the greatest altitude above the ocean level, may have been the deepest submerged, or may' have risen last. Those points also, in the state which show less altitude above the the ocean may have risen first, or may not have been submerged at all. Whatever may be the facts in regard to the northern portion of the state, which is considerably less elevated above the ocean than the southern, the seas of the *Cretaceous* certainly covered the most of the southern half of Minnesota, and probably a wide belt along its western border, reaching to the national boundary line on the north. Thus the rough frame-work of the older rocks was furnished with an outer integument which tones down their angularities by filling some of their depressions, the *Cretaceous* beds lying unconformably on them all. No attempt will be made at this stage of the survey to define the limits of the Cretaceous in Minnesota. It is said to occur in the southwestern part of the state, on the Cottonwood river, where it contains beds of lignite that have been mistaken for the outcroppings of the northern rim of the Carboniferous. It has been detected at Austin, in Mower county, where it affords angiospermous leaves. It has been described in Stearns county by Mr. Kloos. It probably occurs at Spring Valley in Fillmore county. At Stillwater is a bed of *tripoli* which is believed to belong to the *Cretaceous*. It is exposed in a little tributary of the St. Croix river about one mile north of the city. Dr. C. A. White has lately announced it at Lime Springs, in Howard county, Iowa, about five miles south of the Minnesota state line. Howard county, in Iowa, is south of Mower and Fillmore counties in Minnesota. Thus the question of the eastern limit of the *Cretaceous* in the Northwest is still an open question. The writer is not aware of any announcement of its existence in the state of Wisconsin. But on the eastern shore of lake Michigan, in the "Grand Traverse region" of the state of Michigan, occur beds of lignite associated with soft, bituminous and green clays that have been regarded as pertaining to the drift.* Mr. A. D. White, of the Michigan survey, since deceased, maintained in 1860, in his unpublished field-notes, that these lignites and clays are not of Quaternary age. Lignites of the same or similar origin also occur on the shores of lake Superior, and have in like manner been ascribed to the age of the drift. It becomes a question of great

*See *First biennial report of progress on the geological survey of Michigan*, 1861, p. 130.

eological interest to determine the age of these lignites, especially
lignites supposed to occupy a position near the bottom of the rift, also are reported in southern Illinois and Ohio. Besides the gnites connected with the *Lower Cretaceous*, Dr. F. V. Hayden escribes many beds of lignite in the *Lower Tertiary*. What poron, if any, of the lignite beds seen in different parts of Minnesota ay be of *Tertiary* age, it is not now within the province of the irvey to state. The *Tertiary* may also be represented.

The rocks of this age being so little known and so meagerly represented in Minnesota, the following classification will be of value r the information of the citizens of the state and for convenience f reference in the future progress of the survey. It is essentially iat of Messrs. Meek and Hayden, and is based on their examinaions on the upper Missouri. It is arranged in descending order.

ATER CRETACEOUS.

No. 5. *Fox Hills group*. Yellowish and ferruginous sandstones and arenaceous clays. Characteristic fossils—*Nautilus Dekayi, Ammonites placenta, Ammonites lobatus, Scaphites Conradi, Baculites ovatus, Mosasaurus Missouriensis*. Thickness....... ....500 feet.

No. 4. *Fort Pierre group*. Dark clays; plastic or laminated; sometimes calcareous. Characteristic fossils—*Nautilus Dekayi, Ammonites placenta, Ammonites complexus, Baculites ovatus, Baculites compressus, Helicoceras Mortoni, Inoceramus sublevis, Mosasaurus Missouriensis*. Thickness........... ....700 feet.

ARLIER CRETACEOUS.

No. 3. *Niobrara group*. Grayish, calcareous marl, sometimes in massive layers of chalky limestone suitable for building. Characteristic fossils—*Ostrea congesta, Inoceramus problematicus, Inoceramus aviculoides, Inoceramus pseudo-mytiloides*. Thickness...........200 feet.

No. 2. *Fort Benton group*. Black, plastic or laminated clays, with some thin layers of limestone and sandstone. Characteristic fossils—*Inoceramus problematicus, Inoceramus umbonatus, Ostrea congesta, Pholadomya papyracea, Ammonites percarinatus, Ammonites vespertinus, Scaphites larvæformis*. Thickness.... ....800 feet.

No. 1. *Dakota group*. Yellowish, reddish and whitish sandstones, with some arenaceous clays and even pudding-stones, embracing lignite and impure coal, with many impressions of angiospermous leaves, and sometimes large quantities of petrified wood. Characteristic fossils—*Pharella Dakotensis, Axinæa Siouxensis, Cyprina arenaria, leaves of angiosperms*. Thickness............... .....400 feet.

(b.) *Lithological characters of the Cretaceous.**

The stone exposed at Austin, in Mower county, is, in its natural color, light blue, and that color shows on most of the quarried

*The rock here described is of the Devonian. The fossil leaves mentioned were from Cretaceous shale lying in cavities in the rock.—N .H. W.

blocks about the heart of the bedding; and on deep quarrying it is doubtless all blue. Yet the stone seen about the village is very generally of a buff color, to the depth of half an inch to three inches, depending on the amount of weathering and oxidation. The thinner beds are altogether changed to that color. The presence of considerable concretionary iron and mud balls causes a rusty stain of a yellow color over the surface of many of the slabs. These concretionary balls fall out or dissolve out when in the water, and leave cavities which become larger still. Besides these, which are not common in the compact portion of the stone, but are oftenest seen among its thin beds, there are also cavities disclosed by the fracture of the homogeneous thick beds. These are sometimes perfectly empty, but often contain loose friable matter, easily picked out but not different in color or grain from the mass of the rock. At other times such cavities, revealed on the fracture of the stone, are lined with a perfect coating of fine mammillated crystals which are naturally white and as hard as quartz, but often covered with iron-rust so as to present a red or black exterior. They are much like drusy quartz. The texture of the stone itself is usually close, and the grain is homogeneous. Some large slabs and blocks are sawn for bases to tombstones, and worked down to a very smooth surface. It is more safely sawn to any desired dimensions than cut or broken, since it fractures treacherously. Yet it is not in the least crystalline. Its aspect at a distance is that of a fine-grained sandstone. Yet it contains no apparent grit. It is so soft that it can be cut without difficulty, appearing much like an unusually indurated blue shale. It contains, but very sparingly, a few molluscous fossils which appear like a *Gryphæa*. It evidently weathers away fast, since the rotted down beds have to be removed at the quarry to the depth of nearly four feet before any stone is met worth taking out.

Just back of the place where this stone is slightly worked at Austin, perhaps fifty rods distant and 14 feet higher, in the excavation of one of the low knolls which superficially appeared to be only sand, like others opened for that purpose nearer the river, a German struck stone of the same kind within two or three feet of the surface. It consists of thin, shattered beds, all of a buff color. Enough, however, was obtained, of suitable quality, for the vault and other masonry appertaining to a small brewery. Indeed the greater portion of the cellar is dug in it. It was overlain by the

following section of clays, which may not be of *Cretaceous age.*

No. 1.	Black sandy loam and soil	2 to 4 feet.
No. 2.	Band of red and variegated compact clay	6 in. to 4 feet.
No. 3.	Yellow ocherous band of clay	6 in. to 4 feet.

These bands of clay (Nos. 2 and 3) are not so regularly superimposed as indicated by the above section, but occasionally No. 3 is broken through or is wanting, and No. 2 lies on the rock, or passes down into its crevices. Yet No. 3 is generally the first over the rock. They vary in thickness and swell out in shapeless masses of hard clay. Such hard masses are seen sometimes to embrace bits of angular, earthy rock, much like ocher, varying in color from a dark burnt-umber color to a lighter shade, even to buff, and appearing, when of a lighter color, much like the mass of No. 3. They can be scratched easily with a knife, and however black they may be they give a red hæmatite streak. Yet when they are faded the streak also fades into a brown or yellowish-brown, like limonite. Intermingled very irregularly with No. 2, and sometimes also with No. 3, are masses of greenish clay which has in every other respect the same outward characters as No. 2. On searching for indications of the post-Tertiary age of this deposit, none could be found. No northern pebbles or boulders could be found in it; no sand or gravel, no vegetable or animal remains. Yet in place of the northern drift materials are these hard bits of ocher (?) of angular shape and often showing conchoidal surfaces. There are also large crystalline, detached masses of apparently a siliceous limestone which is very hard and close-grained. In some cases, however, this varies to a porous and white limestone that appears to be very pure. In connection with this description of limestone masses, it is interesting to note the occurrence at St. Charles, in Winona county, of hard, siliceous limestone masses on the surface of the ground, that appear very much like those embraced in this clay. At St. Charles there is also a large mass of argentine, or lamellar calcite, lying on the surface of a slope of a hill. It was originally four or five feet across, and about a foot thick, but has been broken up for hand specimens. It appears very much like fibrous gypsum. Its arrangement in wavy and curly layers gives it much the appearance of woody fiber, and it was regarded as a specimen of petrified wood for a number of years after its discovery. It may have been originally embraced in *Cretaceous* or *Tertiary*

clays which have been destroyed and transported, or it may have weathered out from the *Trenton* shales which appear in the top of the hill.

At Austin, in the digging of Mr. L. G. Basford's well, angiospermous leaves were found in the sandstone above described. The materials passed through in this well were said to be in general, as follows:

No. 1.	Soil and loam	3 to 4 feet.
No. 2.	Clay	20 feet.
No. 3.	Rock	6 to 8 reet.

About two feet of loose stone was thrown out by picking. In these pieces the vegetable fossils were found. Two distinct varieties of leaf are disclosed. One is very much like *Ficus primordialis;* the other is unlike anything with which it has been possible yet to compare it. The specimen preserved consists of a branch apparently of a small herb. An inch and three-fourths of the main stalk is preserved. In that distance it gives off four branches, each of which seems to be as large as the main stalk, three on the left and one on the right. The whole specimen is thickly furnished with decurrent, parallel-veined leaves which have a distinct midrib. These leaves are simple, entire, oblanceolate-linear, and taper-pointed at their junction with the stalk. Their length is a quarter of an inch, varying a little above and below that size; and their width is one-twentieth of an inch. The diameter of the stalk, and that of the branches, is about half the width of the leaves. The latter diverge from the branches at an angle 40° to 45°. A photographic copy of this fossil was submitted to Dr. J. S. Newberry, who pronounces it probably a species of *Sequoia*, a gymnosperm of the Pine family known as "Redwood."

At J. Gregson's mill, two miles down the Cedar from Austin, the same rock as at Austin is observed forming a ripple so as to induce the construction of a water-power for flouring purposes. The stream here works down over about fourteen feet of rock. The beds are sometimes two feet or more thick, or the rock is entirely massive like an indurated shale. Yet in weathering the thick beds are checked by planes running mainly horizontal, instead of perpendicular or diagonal as in most shale. Although mainly horizontal, these planes are apt to unite after a few feet, splitting the heaviest beds out lenticularly. On considerable exposure the weather entirely disintegrates and destroys it. It is here worked a little below the dam, and some heavy and fine-looking slabs are

taken out near the water's edge. Some parts are here plainly somewhat calcareous, and afford traces of fossil remains which have much the appearance of brachiopoda. These portions are porous as by absorbed fossils.

At Messrs. Rosenberry and Miner's quarry, near Mr. Gregson's mill, the exposed section is as follows, in descending order:

Section near Austin, in Mower county.

No. 1.—Black, loamy soil	7 to 8 ft.
No. 2.—Loose fragments of the underlying beds, and clay, mixed...	3 ft.
No. 3.—Heavy stone like that described at Austin, clay filling planes and joints	10 to 12 ft.
No. 4.—Rusty bituminous films	½ to 1 in.
[On the authority of the owners of the quarry, to this section may be added, below the foregoing, the following:]	
No. 5.—Limestone, filled with shells, blue, contains flint, makes lime, penetrated	2 ft.

The bedding of No. 3 sometimes lies in detached blocks before being quarried, the corners and angles of which are replaced by clay, and the color of the stone is changed from blue to buff or drab to the depth of about two inches.

Along the sides of this quarry is considerable blue clay, containing no shells or fossils of any kind. It is exceedingly fine and plastic. It fills the openings in the rock, and is said to run down thirty feet at least, where the stone itself would naturally lie unless the beds have been considerably broken and removed. It seems to occupy a trough-like excavation in the rock about a rod wide, and has been traced by means of an iron rod several yards back from the river bank. This clay below twenty feet becomes white. This trough extends east and west.

One mile below Gregson's mill, at the mouth of Rose creek, about the same thickness of the same kind of stone may be seen in the bank and bed of the creek.

It is exposed again at Officer's mill, one mile below Rose creek, where the river passes, in the form of a little ripple, over the rock, inviting here also the improvement of the water-power.

Two miles east of Officer's mill, a farmer has struck the same rock in two separate wells on his farm, in one at the depth of three feet, and in the other at eleven feet.

Below this place no rock is said to occur in the river, differing

from this, till at or near Mitchell or Osago, in the state of Iowa, twenty-eight miles from Austin, where quicklime is made from rock taken from the bank of the river.

Mr. Thomas Smith, on S. E. ¼ sec. 12, T. 102, R. 17, a few miles east of Austin, has discovered coal in the sinking of one or two wells on his farm. It has not yet been possible to compare this locality with that on the Cottonwood river, where coal is said also to occur in limited quantities; but they are both believed to be beds of lignite appertaining to the *Lower Cretaceous*. These localities will both be visited early on the opening of another season of field-work.

At Spring Valley, in the western part of Fillmore county, is an extensive bed of variegated and white clay that is generally very fine, but also sometimes embraces coarse sand grains.

Near Mankato, in Blue Earth county, the banks of the Minnesota river disclose sections of variegated and white clay.

It is not intended here to convey the fixed belief that these clays are of *Cretaceous* age. They occur in other places in the southern part of the state, and time has not yet been afforded for giving them the requisite examination. These remarks are appended to the foregoing description of rocks supposed to be of the age of the *Cretaceous*, because these clays have been seen frequently associated with those rocks, and because they do not appear to be of *Quaternary* age. When chemical examinations of these clays have been made, more positive information concerning their age and value will be received. Samples from different parts of the state have been duly collected, and submitted to the chemist of the survey.

(c.) *Economical value of Cretaceous.*

The sediments of the *Lower Cretaceous* being mainly siliceous are made up of sandstones and arenaceous clays. These clays may be distinctly arenaceous, or the sediments may be so fine that the individual grains are not distinguishable by the unaided eye. The sandstones at Austin are very fine-grained. They are utilized by Messrs. Rosenberry and Miner in the construction of bases for monuments. These blocks are sawn out by the proper machinery and given a high polish by the usual methods. The closeness and fineness of the grain render the stone capable of taking a very

smooth surface. By first marking with a steel point, and properly guiding the fracture, it is cut into pieces of any dimension. Its perfect homogeneity of texture enables the cutter to depend on its checks. It makes very fine hones for razors and cutlery. It is also used instead of the celebrated "Scotch hone" for polishing marble. It is being introduced for that use into the chief markets of the Northwest from the quarry of Rosenberry and Miner. It is furnished by them to wholesale dealers in Chicago at $25 per ton. It is retailed at forty cents per pound, the Scotch hone selling for fifty cents per pound.

The bed of *tripoli* located at Stillwater, in Washington county, seems to consist almost entirely of silica, like this sandstone. Yet, its outward resemblance to many clays that are met with in the drift makes it uncertain to what age it belongs. It lies below a great mass of drift materials closely sheltered in a nook between the bluffs of Brown's creek, and if it be of *Cretaceous* age, its position alone has preserved it from the destroying action of glaciers. It is of a reddish or copper-color, the same as that of the drift clays adjacent. Its exposed thickness is about twenty feet, and it is in some places interstratified with distinct quartz sand. Yet the tripoli clay makes up the mass of the bank, the sand layers being nothing more than partings. About fourteen years ago a company was formed for the purpose of developing this deposit as a material for polishing, but nothing of importance was done. Mr. Abraham Van Vorhes, of Stillwater, is authority for the statement that about that time samples were analyzed by Professor Joseph Henry, of Washington, and by Dr. Jackson of Boston. They agreed in pronouncing it a very fine article of tripoli, equal to the Bohemian. It is at present only used to a limited extent by machinists for polishing brass and iron, and by cabinet makers for polishing varnished wood-work. A thin paste is made and the material applied usually with cork.

The clay at Rosenberry and Miner's quarry, near Austin, in Mower county, is used for putty, by simply mixing it with boiled linseed oil. It is first dried and thoroughly pulverized. It is said to act as firmly as Spanish whiting. The orcherous clays may in some places be made useful in the manufacture of a fine mineral paint.

At New Ulm, in Brown county, are two flourishing potter's establishments, owned by Messrs Dauffenbach and Gieseke, and by John Stekoert. At the former a blue clay "from the Cottonwood"

is mixed with a similar blue clay obtained from the drift at New Ulm. The latter overlies a heavy stratum of waterwashed and stratified white sand. It is said to be necessary to mix these clays to obtain a material that will not crack in the kiln, that "from the Cottonwood" being much addicted to that fault. The same clay makes a red brick when harder burned. A white clay is also used by Dauffenbach and Gieseke for making fire-brick. Their kiln and fire-arch are built of brick of their own manufacture from this clay, and appear to stand well. This clay is obtained at some distance from New Ulm, at a point said to be known only to the proprietors.

VI.

PLANS AND RECOMMENDATIONS.

The law under which the present survey is being prosecuted appropriates the sum of one thousand dollars per annum. This is too small, for various reasons, the chief of which are:

1st. It will not pay for the services of a single employe on the survey capable of working under the law. Hence, it well-nigh renders the law inoperative.

2nd. It does not command the respect and confidence of the citizens of the state and others, and serves as an excuse for refusing aid and co-operation. The survey should be independent of favors for which it now has to beg, sometimes to be scornfully rebuffed.

3d. In the survey of those portions of the state inaccessible by public roads, or by railroads, it will be necessary to employ laborers, and incur other expense, for which the sum of one thousand dollars is not sufficient.

4th. In order to conduct the survey on one thousand dollars per annum, the state geologist must find some other employment a portion of the year.

5th. The magnitude of the interests involved demands that ample means be allowed for doing the work of the survey thoroughly and without embarrassment.

These considerations ought to induce the Legislature to increase

the amount now appropriated to a sum sufficient at least to keep one man constantly employed, and to pay all expense of field-work and chemical examinations.

In connection with the subject of increasing the means provided for the geological survey, it is suggested that the state lands known as *salt lands* may be so sold or appropriated, under the management of the board of regents of the university, as to be available for that purpose. It would be in perfect consonance with the original design in the reservation of these lands from sale, if they were placed in the custody of the board of regents, conditioned on their use in the prosecution of the geological and natural history survey of the state, with a view to the early and economical development of the brines of the state.

The law cannot be carried out without the purchase of chemicals and apparatus for the use of the chemical department of the survey, and without the purchase of instruments to be used in the prosecution of the field-work. It is too much to ask the state university, which now pays the services of the chemist of the survey besides furnishing rooms for laboratory work, to provide for these expenses. There ought to be a special appropriation of several hundred dollars to make these purchases. The board of regents are referred to the accompanying statement of Prof. D. P. Strange, chemist of the survey, for information on this subject.

The law creating the survey is very explicit in defining the work to be done. It requires that the geological survey proper, unless otherwise ordered by the board of regents, shall be first completed. Hence no steps have been taken toward the performance of anything not strictly *geological.* Indeed it is beyond the means afforded at present to do any work in the botanical and zoological departments, before the substantial completion of the geological portion of the survey. It is evident, however, that the aggregate expense of the geological and natural history survey will be considerably reduced by carrying on the different departments in conjunction. It would be duplicating at considerable expense, the various parties and explorations, to delay all observations and collections illustrative of the zoology and botany of the state till after the geological observations had been made. Parties would have to be sent again over much of the same territory. A special botanist or zoologist might accompany the geological party without much additional expense, making valuable collections that might other-

wise be lost. Thus in an economical sense, as well as in a grander and deeper sense depending on their co-adaptation, these sciences cannot be divorced. They cannot act independently of each other. In the prosecution of the geological survey many opportunities will be offered for the furtherance of the botanical and zoological investigations.

Prof. E. H. Twining, late of the university of Minnesota, now of the university of Missouri, has furnished the accompanying list of plants found by him growing on the university grounds during his residence here as professor of chemistry in the state university.

In the prosecution of the geological survey proper, after a general reconnoissance with a view to the determination of the general trend of the formations, and the identification of sufficient characters to decide their ages, it will be necessary to enter on the detailed examination of the state by counties. This more special investigation implies the careful delineation of the outlines of the formations with all their windings, as they are found in each county, together with a scientific account of the chemical and mineralogical characters of the rocks found therein. In the progress of the survey the specific names of the fossils pertaining to the various formations will be ascertained, and in the end complete lists of these ancient faunas will be made out, to which will be added descriptions and figures to illustrate any new species that may be discovered. These investigations necessarily require much time and study, to say nothing of the labor of collecting and preserving the specimens.

The question of the existence of brine in the state of Minnesota is one of the most important, in an economical sense, that can be presented for the investigation of the survey. It should not be hastily answered. Too much is involved to be rested on the result of a guess. Too much also is involved to be prejudiced by the failure of unguided expenditures. The tests that may be made ought to be made in the fullest light of all the facts that science with its generalizations can throw upon them. It comes within the scope of geological investigation, and ought not to be hazarded in the hands of empirical novices.

The salt springs said to occur in this state may have either of two origins. They may be the results of overflow of extensive salt basins embraced in the rocky structure of the state, or they may be the result of superficial accumulations similar to the other saline

and alkaline deposits that are scattered largely over the western plains. It is not intended now to give this question the discussion its importance demands at the hands of the survey. No investigation of the phenomena of the regions where these springs exist, has been made. It is only intended to suggest the importance of correct scientific processes in the future efforts for their development.

It is recommended that the law ordering the survey be amended so as to require the board of regents to supply suites of duplicate geological specimens collected to the state normal schools, after the university collection shall have been completed.

Very respectfully submitted,

N. H. WINCHELL,
State geologist.

UNIVERSITY OF MINNESOTA,
ST. ANTHONY, MINN., Dec. 31, 1872.

STATEMENT OF THE CHEMIST OF THE SURVEY.

Prof. N. H. Winchell, geologist of survey:

SIR:—I have to report that I have been utterly unable to do any chemical work upon the geological survey to the present, owing to the lack of necessary apparatus, and also to the impossibility, with present heating facilities in our laboratory, of conducting any chemical analysis during the winter season.

Very respectfully,

D. P. STRANGE,

Chemist of survey.

LIST OF PLANTS.

Mostly herbaceous in the neighborhood of St. Anthony, Minnesota—principally found on the university grounds.
1869—1872.

BY PROFESSOR E. H. TWINING.

RANUNCULACEÆ.

Ranunculus rhomboideus.
R. repens.
R. abortivus.
R. Pennsylvanicus.
R. sceleratus.
Anemone Nuttalliana.
A. nemorosa.
A. Pennsylvanica.
A. cylindrica.
A. Virginica.
A. thalictroides.
Actæa spicata.
Aquilegia Canadensis.
Thalictrum Cornuti.
Delphinium azureum.
Clematis Virginiana.
Caltha palustris.

PAPAVERACEÆ.

Sanguinaria Canadensis.

VIOLACEÆ.

Viola cucullata.
V. delphinifolia.
V. pubescens.
V. pedata.

CRUCIFERÆ.

Turritis stricta.
Arabis lævigata.
Capsella Bursa-pastoris.
Lepidium Virginicum.

GERANIACEÆ.

Geranium maculatum.
Impatiens fulva.

HYDROPHYLLACEÆ.

Hydrophyllum Virginicum.

OXALIDACEÆ.

Oxalis stricta.
O. violacea.

CARYOPHYLLACEÆ.

Arenaria lateriflora.
Stellaria longifolia.
Silene antirrhina.
Agrostemma Githago.

LEGUMINOSÆ.

Lupinus perennis.
L ochroleucus.
L. venosus.
Vicia Americana.
Astragalus Canadensis.
A. caryocarpus.
Psoralea argophylla.
Amorpha canescens.
A. fruticosa.
Petalostemon candidus.
P. violaceus.
P. villosus.
Amphicarpæa monoica.
Apios tuberosa.
Phaseolus diversifolius.
Desmodium acuminatum.
D. Canadense.
Cassia Chamæcrista.

POLEMONIACEÆ.

Phlox pilosa.

SAXIFRAGACEÆ.

Heuchera hispida.
Parnassia Caroliniana.

ROSACEÆ.

Geum strictum.
G. album.
G. triflorum,
Fragaria vesca.
F. Virginiana.
Rosa blanda.
Potentilla Norvegica.
P. Canadensis.

P. Anserina.
P. arguta.
Spiræa salicifolia.
Prunus Virginiana.
Agrimonia Eupatoria.
Amelanchier Canadensis.
Rubus Canadensis.

BORRAGINACEÆ.

Lithospermum canescens.
L. hirtum.
L. longiflorum.
Echinospermum Lappula.
E. Redowskii.
Cynoglossum Morrisoni.

VERBENACEÆ.

Verbena hastata.
V. bracteosa.
V. urticæfolia.
V. stricta.
Phryma Leptostachya.

LABIATÆ.

Mentha Canadensis.
Leonurus Cardiaca.
Lophanthus anisatus.
Stachys palustris.
S. " var. aspera.
Monarda fistulosa.
Lycopus Europæus.
Teucrium Canadense.
Pycnanthemum lanceolatum.
Scutellaria parvula.
S. lateriflora.
Nepeta Cataria.

GROSSULACEÆ.

Ribes floridum.
R. Cynosbati.

CAPRIFOLIACEÆ.

Sambucus pubens.
Viburnum.
Symphoricarpus occidentalis.
Lonicera.

RUBIACEÆ.

Galium boreale.
G. triflorum.

CORNACEÆ.

Cornus circinata.

ARALIACEÆ.

Aralia racemosa.

UMBELLIFERÆ.

Sanicula Marilandica.
Cicuta maculata.
Pastinaca sativa.
Thaspium.

CUCURBITACEÆ.

Echinocystis lobata.

ONAGRACEÆ.

Epilobium coloratum.
E. palustre.
Œnothera biennis.
O. serrulata.

VITACEÆ.

Vitis cordifolia.

RHAMNACEÆ

Ceanothus Americanus.

LINACEÆ.

Linum rigidum.

MALVACEÆ.

Malva rotundifolia,

HYPERICACEÆ.

Hypericum pyramidatum.

CISTACEÆ.

Helianthemum Canadense.

CAPPARIDACEÆ.

Polanisia graveolens.

FUMARIACEÆ.

Dicentra Canadensis.

SARRACENIACEÆ.

Sarracenia purpurea.

NYMPHÆACEÆ.

Nymphæa odorata.
Nuphar advena.

COMPOSITÆ.

Taraxacum Dens-leonis.
Troximon cuspidatum.
Antennaria margaritacea.
A. Pennsylvanica.
Erigeron Philadelphicum.
E. bellidifolium.
Senecio aureus.
Chrysopsis villosa.
Cynthia Virginica.
Achillea Millefolium.
Rudbeckia hirta.
R. laciniata.
Heliopsis lævis, var scabra.
Coreopsis palmata.
Helianthus strumosus.
H. rigidus.
H. giganteus.
H. hirsutus.
Solidago lanceolata.
S. Missouriensis.
S. latifolia.
S. nemoralis.
S. Canadensis.
S. rigida.
Eupatorium purpureum.
E. perfoliatum.
E. ageratoides.
Sonchus asper.
Lepachys pinnata.
Aster Novæ-Angliæ.
A. cordifolius.
A. azureus.
A. lævis.
A. multiflorus.
A. sericeus.
Lactuca elongata.
Liatris scariosa.
Helenium autumnale.
Nabalus albus.
N. racemosus.
Ambrosia trifida.
Lygodesmia juncea.
Bidens chrysanthemoides.
B. bipinnata.

SCROPHULARIACEÆ.

Rhinanthus Crista-galli.
Castilleia coccinea.
Pentstemon grandiflorus.
P. pubescens.
Scrophularia nodosa.
Veronica Americana
V. Virginica.
Mimulus Jamesii.
M. ringens.
Linaria vulgaris.
Verbascum Thapsus.
Gerardia tenuifolia.
G. purpurea.

Chelone glabra.
Pedicularis lanccolata.

SOLANACEÆ.

Physalis angulata.
Solanum nigrum.

GENTIANACEÆ.

Gentiana crinita.
G. Andrewsii.

POLYGONACEÆ.

Rumex Acetosella.
R. crispus.
Polygonum Convulvulus.
P. aviculare.
P. Persicaria.

CAMPANULACEÆ.

Campanula rotundifola.
C. aparinoides.

LOBELIACEÆ.

Lobelia spicata.
L. syphilitica.

NYCTAGINACEÆ.

Oxybaphus nyctagineus.
O. angustifolius.

ERICACEÆ.

Pyrola elliptica.

PRIMULACEÆ.

Lysimachia ciliata.

ASCLEPIADACEÆ.

Asclepias ovalifolia.
A. tuberosa.
A. Cornuti.

APOCYNACEÆ.

Apocynum and rosæmifolium.

EUPHORBIACEÆ.

Euphorbia corollata.
E. maculata.
E. cyathophora.

SALICACEÆ.

Salix lucida.

ORCHIDACEÆ.

Cypripedium pubescens.
C. spectabile.
Spiranthes graminea.

ALISMACEÆ.

Sagittaria variabilis.

LILIACEÆ.

Trillium cernuum.
Uvularia grandiflora.
U. sessilifolia.
Maianthemum bifolium.
Smilacina stellata.
Polygonatum biflorum.
Allium cernuum.
Lilium Canadense.
L. superbum.

IRIDACEÆ.

Sisyrinchium Bermudiana.

AMARYLLIDACEÆ.

Hypoxys erecta

COMMELYNACEÆ.

Tradescantia Virginica.

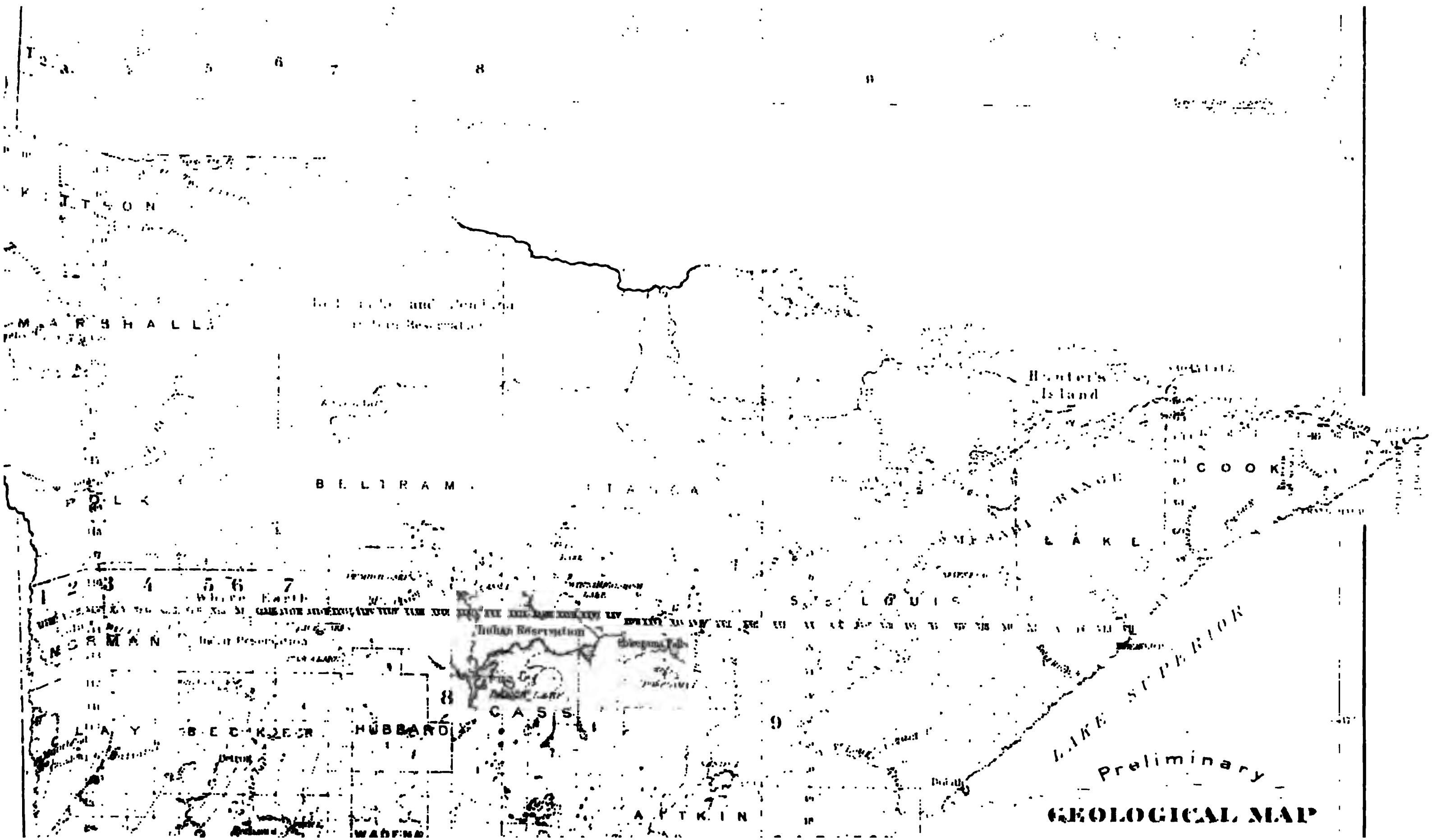
CYPERACEÆ.

Cyperus dentatus.

GRAMINEÆ.

Phleum pratense.
Setaria viridis.
Agrostis vulgaris.
Triticum caninum.
Cenchrus tribuloides.

Note.—The descent of the Mississippi from St. Paul to "grand crossing," opposite La Crosse, is 57 feet, as ascertained through the Milwaukee & St. Paul and Southern Minnesota railroads. If the distance between St. Paul and "grand crossing" be taken at 134½ miles, and if 22½ miles be omitted for lake Pepin, the average fall per mile of the Mississippi river is .509 feet. General Warren ascertained the average descent of the Mississippi from St. Paul to Hastings to be .556 ft. per mile.



MARSHALL
BELTRAMI
ITASCA
COOK
LAKE
ST. LOUIS
CASS
HUBBARD
AITKIN
NORMAN
Hunter's Island
Indian Reservation
White Earth
LAKE SUPERIOR
Preliminary
GEOLOGICAL MAP

Explanation of Colors
Devonian 1
Niagara Limestone 2
Maquoketa Shales 3
Galena Limestone 4
Trenton 5
St. Peter Sandstone 6
Low Magnesian Limestone 7
St. Croix and Potsdam Sandstones 8
Granitic and Metamorphic 9
TODD
MORRISON
MILLE LACS
KANABEC
GRANT
DOUGLAS
BENTON
STEVENS
POPE
STEARNS
ISANTI
CHISAGO
SHERBURNE
ANOKA
SWIFT
KANDIYOHI
MEEKER
WRIGHT
HENNEPIN
MINNEAPOLIS
RAMSEY
WASHINGTON
Stillwater
ST. CROIX LAKE
St. Croix River
LAC QUI PARLE
CHIPPEWA
RENVILLE
McLEOD
CARVER
YELLOW MEDICINE
SIBLEY
SCOTT
DAKOTA
L. PEPIN
LINCOLN
LYON
REDWOOD
NICOLLET
LE SUEUR
RICE
GOODHUE
BROWN
Faribault
WABASHA
Mississippi River
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
La Crosse
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
Preston
HOUSTON
Section from Grand Crossing to Rock County
Vertical Scale, 200 ft. to the inch.

THE

GEOLOGICAL

AND

NATURAL HISTORY

SURVEY OF MINNESOTA.

THE SECOND ANNUAL REPORT.

FOR THE YEAR 1873.

[SECOND EDITION.]

By N. H. WINCHELL, State Geologist,
AND
S. F. PECKHAM, State Chemist.

SUBMITTED TO THE PRESIDENT OF THE UNIVERSITY,
DECEMBER 31, 1873.

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[NOTE—This edition is identical with the original, excepting the correction of typographical errors. As this report was published originally only as a part of the regents' report, it has the paging of that report.—N. H. W.]

ADDRESS.

To the president of the University:

I have the honor to offer the accompanying report on the progress of the geological and natural history survey of the state, for the year 1873. The last Legislature increased the means provided for the prosecution of the survey, by doubling the cash appropriation, making it two thousand dollars annually, and transferred to the board of regents the state lands known as "*salt spring lands*," the proceeds of which they are required to expend exclusively in the prosecution of this work. At the same time the board of regents of the University were required to direct the immediate survey of the peat deposits of the state, and to cause an investigation and report on the salt springs.

While these special investigations have been carried on as far and as thoroughly as possible, the progress of the general survey has also been pushed as far as the means and time would permit.

In general, the field of observations has been, during the season of 1873, in the southwestern part of the state. The valley of the Minnesota, and those of some of its tributaries, have been subjected to a reconnoissance which has served to answer many questions that were important to answer before entering on the detailed county work, and in that manner has also served to prolong, though not yet to complete, the preliminary survey that occupied the short season of 1872. The results of this reconnoissance, both scientific and economical, will be found stated in the proper places in the accompanying report.

The counties of Cottonwood, Jackson and Nobles have been subjected to thorough inspection for peat. Incidental examinations have also been made on peat deposits in the

counties of Dakota, Hennepin, Ramsey, Le Sueur, Nicollet, Faribault and Stearns. Prof. S. F. Peckham, the chemist of the survey, has made the analysis of thirteen specimens. Before his appointment six specimens were also submitted to Dr. P. B. Rose, of Ann Arbor, Michigan, for analysis. The reports of these gentlemen will also be found in the accompanying report, supplemented by remarks on the methods of working peat, and its value as a fuel for general use, and by sundry practical conclusions on the peats of Minnesota.

The question of the existence of Carboniferous coal in Minnesota, has also occupied considerable time during the past season. The frequent statements, positively put forth in the public prints, of the finding of considerable quantities of good coal in the southern and southwestern part of the state, together with the published opinion of Mr. H. H. Eames, reporting to the Legislature in 1866, to the effect that the Carboniferous rocks of the state of Iowa are prolonged northward into Minnesota, and there furnish the "coal" of the Cottonwood and Redwood valleys, induced the attempt to determine, as far as possible, the source of the float coal found, and the real age of the rocks explored for coal in that portion of the state. This question was believed to be paramount to all others bearing on the fuel supply, and although its solution is not entirely accomplished, yet enough has been ascertained to warrant certain practical and important conclusions. The facts on which these conclusions are based, will be found stated in different parts of the following report, and need not be repeated here.

1st. The rocks that have been explored for coal, on the Cottonwood and Redwood rivers, belong to the Cretaceous system, and do not promise to be productive of coal in valuable quantities.

2d. The coal there taken out is of an inferior grade, though varying from cannel coal to charcoal.

3d. As the rocks of the Cretaceous period are believed to have existed throughout the most of the state, the only probable exception being in the southeastern portion, including half a dozen counties, such coal is likely to occur at a great many places.

4th. The "float" coal which has so often attracted the attention of the people, is derived, so far as yet known, from the disruption of the Cretaceous rocks by the glaciers of the ice period. It is scattered through the drift, and

is met with in wells and other excavations, and may be often picked up along the beds of streams.

5th. The only part of the state where good coal-bearing strata of the Carboniferous age may occur, comprises the counties of Mower, Freeborn and Faribault. As these counties are heavily covered with drift, the question can be settled definitely only by drilling or shafting to the rock. Should Carboniferous rocks be met in Faribault county, there would also be some reason for exploring for the same in the southeastern portion of Blue Earth county.

In regard to the investigation of the salt springs, nothing further has been done than to ascertain their history, and the present condition of the United States land grant. It has been found that the original grant covered 46,080 acres. Of this the state was unable to avail itself of 11,520 acres, that amount being situated outside of the area surveyed by the U. S. government. The springs, however, lying outside of the surveyed portions of the state, were carefully located by metes and bounds, and at the order of governor Sibley the request was entered at the Land Department at Washington that the lands appertaining to each spring so located, also those lying within the surveyed portions, claimed by the State under the act of Congress admitting the State into the Union, be withheld from sale and occupancy. They have not been so withheld, and those lands have not been certified to the State. This fact reduced the original available grant to 34,560 acres. It has been further reduced by the occupancy by settlers, 6,752 acres. About 1,600 acres were also previously covered by the terms of the act granting swamp lands to the State. The remainder, 26,435 acres, have been certified to the State. The Belle Plaine salt company were granted 7,643 acres of the certified salt spring lands, on complying with the acts of the Legislature. The rest of the certified lands, amounting to 18,771 acres, are now available for the prosetion of the survey. The uncertified portion of the original grant, aggregating 19,872 acres, inasmuch as the whole was properly selected and located within the terms of the "enabling act," should be the subject of a memorial to Congress, as suggested by auditor McIlrath, in his report for 1871. It is believed that the U. S. government would gladly make up, by an additional grant, the deficiency that has resulted in great loss to the State, through the neglect or inadvertence of its own officers.

The traveling expenses have been materially reduced

during the past season by the courtesy of the officers of the following railroads, who have granted me continuous passes over their roads, viz: the St. Paul and Sioux City, and Sioux City and St. Paul; the Southern Minnesota; the Northern Pacific, and the St. Paul and Pacific.

Dr. I. A. Lapham, director of the geological survey of Wisconsin, has furnished a catalogue of the plants of Minnesota, made up from various sources, including his own observations, and known to be growing in the state at the date of 1865. The reputation of Dr. Lapham for scientific accuracy, not only increases the value of this gift, but makes it highly desirable that its publication be not delayed. Although not strictly of a geological character, yet it comes within the scope of the survey and is herewith presented.

A great many individuals have aided in the prosecution of the survey during the past season. Of these, I can name Prof. Ira Moore, of St. Cloud, who has also donated to the university museum a number of interesting fossils and minerals from various localities; W. Z. Haight, of Delevan, who has taken great interest in the peat investigations, and has furnished much information on the manufacture of peat in Faribault county; Gov. Stephen Miller, of Windom; I. J. Rochussen, of St. Paul; Park Worden, of Minnesota Falls; Henry Hill and A. J. Luce, of Granite Falls, and Capt. H. H. Herrick, of DeGraff, Dak. Ter. I am also under many obligations to the citizens of Cottonwood, Nobles and Jackson counties, for assistance in making the peat survey in those counties.

In the examination of the Minnesota valley I was accompanied as far as to Mankato, and thence up the Blue Earth to Wells, by Mr. P. P. Furber, a student in the university. From Mankato to the head of Big Stone lake, Mr. C. E. Chatfield, also a student in the university was my only companion. The assistance of these young men contributed greatly to the thoroughness and success of the exploration of that valley. We depended on the scattered inhabitants for sustenance, and traveled with a single horse and light, covered wagon. At night we usually slept in our tent, camping near some farmer of whom we obtained meals.

Very respectfully,

N. H. WINCHELL.

THE UNIVERSITY OF MINNESOTA,
Minneapolis, Dec. 31, 1873.

I.

THE BELLE PLAINE SALT WELL.

(a) *General section of the well.*

The report on the Belle Plaine salt well, which was printed by order of the senate, in Jan. 1872 [Ex. Docs. of Minn. for 1872, vol. I. p. 44] covered only that part of the drill above 210 feet, and pertained only to the drift materials, or to the deposits overlying the Silurian rocks. There are some reasons for believing a portion of the loose materials passed through in that distance belong to the Cretaceous. It is known that some portions of that formation consist of loose materials, and they may be mistaken for drift, especially in a region where the soft rocks of that age are not known to exist, by workmen who are not exact observers, but are prone to classify the rocks they happen to encounter according to their visible characters and the ease with which they are penetrated. The occurrence of occasional vegetable fragments is further evidence of the preglacial age of those materials. Since that report was made the well has been sunk to the depth of 710 feet.

The section of the well is thus described by Mr. P. M. Barker, who superintended the work:

Surface and drift	216 feet
Potsdam sandrock	16 "
Ochreous shale	10 "
Soapstone, variegated and mottled	40 "
Semi-igneous formation	108 "
Red shale or marl	6 "
Igneous formation	314 "
Total depth of well	710 "

(b) *Notes and letter of A. Winchell.*

In July, 1872, samples of the preserved drillings from depths from 242 feet to 411 feet were forwarded to Prof. A. Winchell, for examination. His notes and accompanying letter to Gov. Austin are as follows:

At depth of 242 ft.—Highly magnesian clays—purple and speckled with white—mostly without siliceous grains. Generally no conclusive evidence for deciding whether drift or in place. On the whole, I think the fragments are from a formation in place. One of them contains a few quartzose grains, and has a decidedly metamorphic look. All the specimens resemble softened porphyries.

368 ft.—A mass of granules or chips, similar to above, but more uniformly red, and less unctuous. All crush under the knife and exhibit a streak lighter than the mineral—sometimes grayish.

380 ft.—Fragments still more like (242-282) but less unctuous. A broken crystal of calcite.

385 ft.—Fragment (nearly a cubic inch) of a rock, composed apparently of reddish clay and a white mineral, like magnesia or kaolin intimately mixed. The white mineral tending in places to veins. The aspect is decidedly that of a rock in place.

390 ft.—Fragments like (380) but with more calcite, and one slightly polished fragment of glassy quartzite.

398 ft.—Almost identical with (390). From the same depth, however, is a lump of adhesive clay, which is evidently produced by grinding up rock like (242-282).

400 ft.—Essentially like (242-282).

405 ft.—Essentially the same—with one fragment of quartz.

409 ft.—Same.

411 ft.—Same.

There is, in addition, a parcel of fragments from some depth not indicated. Their general character is like that of (242-282). It is easy to see that one of them is a brecciated rock composed of fragments of argillaceous character and quite soft. One is unequally cemented by a deposit of calcite.

From an examination of the specimens and the study of everything that has been written which could bear upon the question, I am led to think the rocks now being bored through, belong to the sub-Silurian series—probably equivalent to the quartzite and pipestone outcropping about New Ulm and in Pipestone county, Minnesota. (White, Io. Rep. I, pp. 169, 170; Shumard: Owen's Rep. p. 491.)

LETTER TO GOV. AUSTIN.

Ann Arbor, Mich., 12 Aug., 1872.

Gov. Horace Austin, St. Paul, Minn.,

SIR: Yours of the 24th of July was found awaiting me

on my return from the east, though the case of specimens did not arrive until August 5th, when I was prostrated by an obstinate fever, which has continued for a week. Improving such opportunities as I have had, I have made a pretty thorough physical examination of the specimens and reviewed all that has been published on the question of their identification and their relations to the geology of Belle Plaine, and I would respectfully report as follows:

1. Neither your note nor the accompanying one from Mr. Hooper intimates whether the materials passed through below 200 feet are wholly of the kind sent, or whether these fragments and masses were found mixed with much clay and sand, and even hard pebbles.

I infer, however, from an inspection of the specimens, that they are samples of rocky strata found in place.

At the same time, their uniform softness for 200 feet is very remarkable, and would suggest that the drill is passing through strata which are highly tilted.

2. Mr. Hooper informed me, last year, that at 202 feet shelly rock had been reached, which, at 210 feet, became solid sandstone and constituted a bed-rock. I inferred that this was the Potsdam sandstone, and still think that whatever there was of it, belonged to that formation. Between 210 and 242 feet, I have no information; and it appears that the sandstone, [a lower sandstone than that at St. Paul,] was completely pierced in that interval or less. The old well was, therefore, very near the bottom, or perhaps quite at the bottom of the sandstone. The ancient valley of the Minnesota river, which probably once discharged the waters of a much wider hydrographic basin, was eroded completely to the sub-Silurian rocks.

3. These sub-Silurian rocks are very remarkable. All the samples are agillo-magnesian, mostly fine-grained, unctuous, sometimes lined and frequently speckled with a white mineral like magnesia or kaolin. They present almost no grains of quartz, but sometimes enclose crystals and seams of calcite. The color is reddish and purplish. Viewed without a test for hardness, they look like vitreous porphyry. I am led to think they represent the formation known to outcrop at New Ulm and in Pipestone county. These clays, in fact, are substantially the catlinite or "pipestone" so well known in that county.

4. If these conclusions are correct, there is no hope, either of salt or a well of fresh water, by boring deeper, and not another dollar ought to be expended in this hope.

5. It will be noted that my recommendation in my former report suggested the propriety of boring *only to the bottom of the Potsdam sandstone.* As there intimated, there are certainly many regions in Minnesota, where a well bored to the bottom of this formation, would prove to be artesian. Belle Plaine, as I feared, does not prove to be favorably located. Places situated for borings, at public expense, ought to be intelligently selected, without any regard to the interests of localities, and the State ought not to be committed to unwise expenditures by the precipitate and ill-advised enterprise of smart business places.

Lest this remark, however, should be thought to apply too severely to Belle Plaine, I ought to add that considerable reason existed for boring at that place--though by no means as good reason as many supposed. The fault committed here as in so many other cases, was an attempt to proceed independently of geological knowledge in the beginning, and to call for scientific aid, not so much to guide an important enterprise, as to help it out of difficulty.

Very respectfully,
A. WINCHELL.

(c) *Notes and report of N. H. Winchell.*

In February, 1873, the writer had occasion to further examine this well, under verbal instructions from Gov. Austin. Samples preserved by the owners from below the depth of 411 feet, were found to have the following external characters. The memorandum is here given, as well as the report subsequently made to Gov. Austin, in order to preserve to science the record of the drill, and to complete the history of the exploration:

At 420 ft.—Ferruginous quartzite, with a considerable admixture of light-colored, softer, apparently talcose fragments. The quartzite is hard, and very impure. The talcose fragments are either nearly white or speckled with rusty and black spots. There are also in the drillings pieces of calcite, a soft, greenish substance that may be silicate of iron, and occasional fragments of translucent quartz, either white or slightly tinted with yellow or with green.

At 430 ft.—A mixture of dark brown or reddish silicates, strongly ferruginous, with slight traces of mica and some pieces of calcite. Some of it appears conglomeritic, or tufaceous. It is slightly unctuous in the fingers, and some of it is real iron ore. The light-colored pieces of the last (420 feet) are rarely seen. There are in it occasionally greenish pieces of quartz. It is evidently a metamorphosed sedimentary rock.

At 440 ft.—A ferruginous, unctuous shale, with very little grit. It sometimes is spotted with a white substance about as hard as talc, which has a greasy feel. This white substance seems to be the same as mentioned in the foregoing. It is sometimes minutely disseminated among the ferruginous portions. When then rubbed in the fingers, a rusty or irony stain covers the whole. Some of this is plainly siliceous and micaceous.

At 450 ft.—About the same as at 430 ft. but darker colored and less firm in the fingers. It is plainly micaceous.

At 460 ft.—Dark greenish-brown, micaceous silicates; hard and compact. Not evidently unctuous. No feldspar is discernible.

At 470 ft.—A talcose, furruginous shale, of a reddish-brown color, with occasional pieces of greenish silicates. In this lot there are also several pieces of evident flesh-colored feldspar.

At 480 ft.—A mixture of ferruginous silicates with some mica and talc and calcite; with occasional pieces also of the soft, greenish substance mentioned at 420 feet. The last is softer than calcite. The general color of the whole is dark red or brown.

At 490 ft.—The same as at 480 feet.

At 500 ft.—The same as at 480 feet.

At 510 ft.—The same as at 480 feet, but more friable, apparently, as the sample is in the form of sand. There are also in this lot several large fragments of ferruginous shale, which have a greasy feel, probably broken from the overlying beds by the bucket and brought up with the drillings.

At 520 ft.—A very dark, ferruginous mixture of the various silicates, including the light green soft substance, resembling silicate of iron. This last also resembles talc, and is as soft.

At 530 ft.—A red arenaceous shale, with some talc and calcite, and also fragments of flesh-colored feldspar.

At 540 ft.—The same as at 530 feet.

At 550 ft.—Fragments of dark red, coarse shale, like the last, and of a darker slightly greenish shale, that appears as if originally amygdaloidal, the cavities having been subsequently filled by the soft green substance mentioned at 520 ft. This latter mass is sometimes closely mixed with small geodes with rusty exterior.

At 570 ft.—A dark brown shale, like the dark shale in the last, closely mingled with the soft, greenish (silicate of iron?)

At 580 ft.—The same as at 570 feet.

At 590 ft.—The same as at 570 feet, but showing a little more red, and also evident pieces of calcite.

At 600 ft.—The same as at 590 feet, but with increasing quantities of the greenish, soft substance.

At 614 to 620 ft.—A mixture of the various silicates with considerable iron, the quartzitic characters being much more evident than at 570 feet. It is also firmer—hardly a shale.

At 620 ft.—The same as the last.

The well is said to be 710 feet in depth, and the opinion is prevalent that there was no change from 620 feet to that depth. As there are no preserved samples below 620 feet, it is also probable that there was no marked change in the rock. If that be correct, it gives a thickness of 292 feet of rock, which may all be classed as a siliceous unctuous shale, highly ferruginous, and sometimes amygdaloidal, va-

rying to a micaceous quartzite. It seems to be a metamorphosed sedimentary rock, lying below both the St. Croix sandstone and the Potsdam sandstone.

On the basis of these notes was made the following report:

REPORT TO GOVERNOR AUSTIN.

THE UNIVERSITY OF MINNESOTA,
ST. ANTHONY, MINN.,
8th Feb. 1873.

Gov. Horace Austin, St. Paul, Minn.:

According to verbal instructions from you, given on the 6th instant, I proceeded yesterday to Belle Plaine, for the purpose of making examination of the premises and the preserved samples of the drillings from the well sunk at that place, for testing the rocks for brine. The object of my visit was to ascertain the propriety of further expenditure by the State at that point, either for the purpose of proving the rock further for brine, or for purely scientific results.

I did not enter into a careful examination of the derrick and machinery, but suppose them to be, as represented, in perfect order, and ready for operation at any time. The springs that are said to be briny are situated near the drilled well. I obtained a sample of the water for analysis. To the taste it does not show brine, but a careful examination may prove it to hold a small amount of salt.* These springs issue from the base of the drift bluffs that enclose the river valley, and, according to all the information I could gather, are dependent altogether on the surface deposits for their supply. The owners of the well also say they have met no indications of brine in the well since they struck the rock, but that at varying depths in the drift materials, the water pumped out showed more or less saline property. The drift materials are said to have proved to be there 216 feet in thickness.

The preserved drillings which I examined pertain to that part of the well below 420 feet, and I can report only on that portion of the well. They extend moreover only to the depth of 620 feet. The well is said to be 710 feet deep. Without entering into details as to the character of those drillings, a matter that will find place in my next annual

*See the report of Prof. Peckham.

report, I may say that they consist in general of a siliceous, apparently talcose, shale, varying to a micaceous quartzite. It seems the whole thickness covered by the drillings I saw, is taken up with a metamorphosed sedimentary rock that lies below the St. Croix sandstone, and also probably below the Potsdam sandstone. Hence the bottom of the well is in the Huronian slates and schists, but has not yet struck the granite. In this statement it is presumed that the interval unrepresented by drillings (from 620 feet to 710 feet) is filled up, according to the opinion of the owners, by the same general class of rocks. I have no hesitation in saying that *in the rocks of that age there is almost a certainty that no salt would be obtained, and that no lower formation would offer better inducement to sink the well deeper.*

The only other reason for sinking the well deeper is on purely scientific grounds, viz. : to ascertain the character of the rock below the present bottom of the well.

In respect to this I wish to say :

First.—The well is not located where the most light could be thrown on the geology of the state by such an exploration. There are vast districts where even the nature of the outcropping rock at the surface is unknown, to say nothing of those that succeed it in descending order. The geology of the vicinity of Belle Plaine is pretty well made out, especially in the light of the developments of this well.

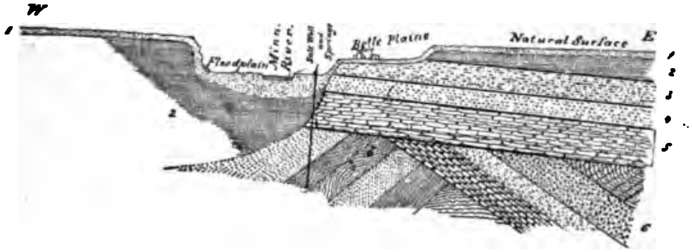
Second.—The rocks that would succeed that in which the drill stopped would be best examined where they are abundantly exposed at the surface. They belong to the class of "granitic and metamorphic" rocks, colored on my preliminary geological map of the state, and our knowledge of them is at present so limited, that before their natural outcrops are examined carefully, it is not certain that we should derive satisfactory and useful information of their nature, by sinking a drilled well through them, or into them. They are the rocks, moreover, that are least likely to need such exploration, on account of their being extensively tilted and broken by early volcanic forces so as to expose their thickness and contents to the inspection of the geologist.

Third.—It cannot be denied that the science of geology might be considerably advanced by sinking this well deeper—presuming all the time that careful records be kept and samples be submitted to a geologist for examination. It is

at the same time certain that no important question, involving the geology of the state, is pending on what might be developed.

The question may arise--if there is salt in the water at Belle Plaine, what is its source, and can it be made useful? If there be salt in the spring water there, it must issue from some part of the drift. It may be derived at first from some of the underlying formations, as the St. Croix sandstone, or the Lower Magnesian limestone, or it may come from the Cretaceous, which lies in many places unconformably on all the older rocks, but is generally deeply covered by drift. In either of these cases it would be best and soonest developed by drilling at some point east of Belle Plaine, say fifteen miles, as the rocks dip in that direction. The annexed diagram illustrates the situation of the well drilled, in respect to the rocks, and shows the positions of the formations and their dip. None of these formations, however, are known to contain brine in this country, if we except doubtfully the Cretaceous, while yet it is theoretically true that any sedimentary formation, if porous, may hold brine, if so shaped that it has not drained out.

DIAGRAM OF THE GEOLOGICAL RELATIONS OF THE BELLE PLAINE SALT WELL.



No. 1.—Drift. No. 2.—Cretaceous. No. 3.—Low. Magnesian. No. 4.—St. Croix sandstone. No. 5.—Potsdam sandstone. No. 6.—Metamorphic and granitic.

In conclusion, I am at present of the opinion that if there be salt in the springs at Belle Plaine, it is derived from the Cretaceous rocks, but manifests itself in the drift at the base of the river bluffs, because the surface drainage is in that direction, there being a slow but constant loss of brine by that means. This subject ought to have early attention.

I wish to call your attention to the necessity of combining the records and minutes made prior to the depth of 420 feet, with those I have made on the drillings below 420 feet, so that the whole be preserved to science. The owners think those samples were forwarded by you to Ann Arbor, Michigan, and that a letter from my brother to you has has some mention of them.*

Very respectfully,

N. H. WINCHELL.

THE UNIVERSITY OF MINNESOTA,
February 16, 1874.

Prof. N. H. Winchell:

MY DEAR SIR:—In answer to your enquiry in reference to the progress of the analysis of the Belle Plaine water, I have to report, that while the work is not yet completed, enough has been done to show that it contains only a small proportion of chlorides of any kind, and also to justify the statement that the brine belongs to the class of "bitter brines," containing more sulphates than chlorides, and a larger proportion of alkaline earths (lime and magnesia) than alkalies (soda and potash.) I have found nothing as yet in my examination of this mineral water to justify the expectation that it can be made of any commercial value as a source of common salt.

Very truly yours,

S. F. PECKHAM,

Chemist of the geological survey of Minnesota

*This letter has already been given—See p. 80.

II.

PEAT.

(a) *Need of fuel—Objects of the peat survey.*

The absence of wood and coal from a large part of the settled portions of the state, and the consequent high price of fuel for domestic use, induced the last Legislature to insert a clause in the "act to aid the Geological and Natural History Survey," requiring the immediate survey of the peat deposits of the state, a report on the same to be made to the Legislature as soon as practicable. In that way it was hoped that a good fuel might be obtained, practicable for all the common uses of the settler; and that a great many of the hardships of the first settlers of the prairies of the state would thus be relieved. While this law was not intended to work a suspension of the other geological investigations required by the general law creating the survey, its immediate and practical importance has nevertheless controlled the course taken in the routes of exploration, and absorbed much of the time throughout the whole season.

Allied to the subject of peat is that of coal. It was deemed best that the two should be prosecuted together, especially as the locality of the rumored coal exposures coincided with that of the greatest need for fuel, and again with that in which peat was supposed to exist. The southwestern quarter of the state, including the Minnesota valley and those of some of its tributaries, have occupied the principal part of the season. In addition to these explorations, the counties of Cottonwood, Jackson and Nobles have been pretty thoroughly surveyed for peat. The northeastern portion of Jackson and the northwestern portion of Cottonwood should be further examined. The question of the occurrence of coal, and its origin and nature, is mentioned under the head of "The Economical Geology of the Minnesota Valley."

(*b*) *The varieties of peat.*

In order to a perfect understanding of that which follows, it will be well to mention the different varieties of peat, briefly describing the nature and habitat of each, and the terms by which they will be designated. The different products of a vegetable nature that have attracted attention under the general term *peat*, and have served to some extent for fuel in the state, may be classified as follows:

1. Slough peat.
2. Side-hill peat.
3. Turf-peat.
4. Turf.

Only to the first two of these is the term "peat" properly applied, yet among the common people they are all frequently embraced under that term.

1. *Slough peat*, is that which is found in low ground, occupying the lowest spots in old drainage courses which are now either entirely destitute of currents of running water, or are only filled in the wet seasons of the year, or occurring in the depressions among the drift hills or knolls, the slow drainage from which prevents the accumulating water from standing for too great a length of time above the usual level. In southwestern Minnesota such peat must be so situated also that the slough which holds it never becomes dry, else the prairie fires will certainly consume it. Hence, the necessity of constant springs of water to supply the slough in the dry months of the year. This again implies that the surface of the country must be rolling, at least that some bluffs of drift gravel must lie adjacent to the slough to give origin to springs of water. These springs are very often invisible. Their existence may be known, however, by the standing of the water of the slough at the same level, even in the dryest seasons. In case such peat lies in an old drainage course which shows no great flow of water in the dry season, the low spots containing it are still supplied with water enough to preserve the peat, by the slow, invisible, underground drainage pertaining to the valley. These correspond to the German *Wiesenmoore*.

The primary and essential ingredient that goes to form this kind of peat is a fine moss that grows over the surface of the bog, among the coarse stalks of other vegetation, such as grasses or rushes, making a handsome green surface. At a distance this moss cannot generally be seen. It is hid by the coarser vegetation. Besides this moss, the

roots and decaying stems of the grasses and other aquatic plants that may grow in the slough, also aid in the peaty accumulation. This moss is *Shagnum palustre*,* and the aquatic plants that accompany and hide it are bulrush (*Scirpus*), scourish rush (*Equisetum*), a short "blue-joint" grass, and occasionally the cat-tail (*Typha latifolia*), and species of *Polygonum*, and some others.

There is, besides the typical moss peat of the sloughs, a pulpy deposit in the bottoms of many small lakes and ponds derived from the coarse grasses and sedges that grow about their margins, which consists principally of vegetable matter, and if treated properly will make a useful fuel. It is in the form of a fine silt, and is usually too limited in quantity, and too impure in quality to be very valuable. It is apt to be most abundant on the leeward side of the lake, where the prevailing winds have driven it, and the waves have beaten and broken it. This corresponds to the *Schlammtorf* of Holland.

2. *Side-hill peat.*—This is formed on the side of a gentle declivity where springs of water furnish the necessary constant moisture. It is apt to accompany those springs that lie in belts, marking the outcropping upper edges of shale beds or other impervious rock. It is composed of the same materials as slough peat, but is more liable to be impure, from the sand and dust that are carried upon it by the high winds of the plains. Such peat may accumulate to the depth of six or eight feet. It is far less common in southwestern Minnesota than slough peat. It requires also a rolling surface that may give rise to unfailing springs. Many springy side hills that in a moister climate would become peat-bearing, dry up in summer to such an extent, in southwestern Minnesota, that no aquatic plants can survive, and no peat can be formed on them.

3. *Turf-peat.*—This is formed of the roots and fallen stalks and blades of the rank grasses and sedges that grow in the shallow sloughs, or about their margins, in situations moist enough to resist the prairie fires. It is found sometimes on a side hill or in a narrow ravine or inclined slough through which there is a slow seepage of water. It is always more impure than the foregoing varieties, and becomes mixed with sand and black mud below the depth of 12 or 18 inches, so as to render it unfit for use. It is always fibrous and conveniently handled. Owing to its being so

*This is the common term. Dr. C. A. White has, however, given the name ***Hypnum aduncum*** to the peat moss of Iowa.

hard as to support the weight of a man, or often of a team, in the dry months of the year, its accessibility and the ease of taking it out by simple means, it is probably the most useful variety of peat to the farmers of southwestern Minnesota. It is also the most common. In very dry seasons the fires get into this turf-peat and consume vast quantities, burning for several weeks, or even till mid-winter. It is invariably found about the margins of the little depressions in the general prairie which contain water in the spring of the year, but become nearly or quite dry in the summer. The peat itself is annually submerged for several weeks in the spring. It lies on a hard and impervious drift clay, which is generally very fine, and blackened to the depth of a foot or more by the charred vegetation of many generations.

4. *Turf.*—This is the common sod of the prairie. It passes into the last. It is made of the prairie grass roots, and those of other vegetation that may grow there. In dry sloughs, that furnish a fine growth of hay annually, it is sometimes fit for fuel, but it rarely becomes thick enough to make it of much use for that purpose. It always contains considerable sand and clay.

(c) *The quality of Minnesota peats.*

There is nothing in Minnesota, so far as yet discovered, that answers to the extensive *moors* or *heathers* of the moist climates of Ireland, Holland and North Germany. They occur on the northeast coast of North America, in Labrador, Newfoundland and Anticosti, where the summers are not so excessively warm, and where frequent fogs give the atmosphere that state of moisture which the peat mosses require. Along the low lands on the south coast of Anticosti "a continuous plain covered with peat extends for upward of eighty miles with an average breadth of two miles; thus giving a superficies of more than a hundred and sixty square miles."* It has a thickness of three to ten feet. In the wooded portions of the state the peat deposits are likely to be made up of more or less coarse vegetation, such as deciduous leaves, and the stems and roots of various ericaceous plants. In the extensive peat deposits of the old world the vegetable fiber is entirely destroyed below a depth of ten or fifteen feet, and the peat has a compact, earthy texture, and a black or brown color.

*Geology of Canada, 1863.

The peat deposits of Minnesota are, so far as known, too shallow to exhibit this perfect decomposition, and hence, they are generally distinctly fibrous from top to bottom. In the lower portions of the deep peat bogs of Ireland the per cent. of ash is much greater than near the surface, reaching sometimes as high as nineteen per cent. those portions near the surface, which contain the vegetable matter but little altered, affording but one and a half per cent. Thus, while the density of peat, and hence its usefulness for domestic fuel, are enhanced by the greater depth, its combustibility and its purity are diminished. The superficial layers have nearly the same composition as wood. The foreign substances, that constitute the ash of the lower portions, are lime silica, iron and clay. The lime is derived from the small shells that often inhabit the bog, and which sometimes are so abundant as to have caused, by their accumulation, a bed of shell-marl at the bottom of the lake before the growth of the peat mosses filled it. Such shell-marl beds often occur at the bottom of peat bogs. Silica may have entered the growing peat by being blown on in the form of sand, or washed in by freshet rains from the adjoining hills. Iron is found in nearly all water in its natural state. As a carbonate it may be carried in solution by spring water issuing from ferriferous gravel or sand. On exposure to the air it is converted to a hydrated peroxyd, which is precipitated as a red film on all substances. If long continued it would thus form a bog ore, or brown hæmatite. It would descend by its specific gravity to the bottom of the peat bog. The clay that makes a part of the ash of peat is a composite substance. Its chief ingredient is alumina. It may also be carried into the bog by small streams so as to mingle with other impurities in the greatest proportion at the bottom. By reference to the accompanying chemical analyses, performed by Dr. P. B. Rose, of Ann Arbor, Mich., and by Prof. S. F. Peckham, chemist of the survey, it will be seen that a great diversity exists in the qualities of the samples of peat from Minnesota, but that they compare favorably with peats analyzed from Iowa, Connecticut, or even the famous Irish peat.

(d) *Peat analyses by Dr. Rose.*

Of the peats analyzed by Dr. Rose, the samples numbered 1 and 2 were procured and furnished the survey by Dr. C. D. Williams, of St. Paul. No. 3 was furnished from

the manufactory by W. Z. Haight. No. 4 was obtained by the survey, and is named in the section describing it, "peaty, lake sediment." No. 5 is properly not a peat, but a turf-peat, as defined on page 90. No. 6 is a fair sample of raw peat, from Wells, in Faribault county, obtained by the survey. The corresponding serial numbers in the records of the survey, run from 5 to 10 inclusive.

Prof. N. H. Winchell, state geologist of Minnesota, St. Anthony Falls, Minn.

DEAR SIR:—The six samples of peat furnished me by express, and marked as follows:

No. 1—Schmidt's land, St. Paul—taken out eight feet below the surface;
No. 2- Schmidt's land, St. Paul—two feet below the surface:
No. 3—Manufactured peat, from Wells:
No. 4—Lake Emily, near St. Peter;
No. 5—Empire City:
No. 6—From Wells, not manufactured:—

have each been submitted to an analysis, with the following results: 100 parts of the air-dry peat contain—

	Hygroscopic water.	Ash.	Organic matter.
Peat No. 1 (Serial No. 5)	13.75	12.73	73.52
Peat No. 2 (Serial No. 6)	12.65	21.67	65.68
Peat No. 3 (Serial No. 7)	14.00	18.17	67 83
Peat No. 4 (Serial No. 8)	9.83	67.17	23.00
Peat No. 5 (Serial No. 9)	8.83	77.35	13.82
Peat No. 6 (Serial No. 10)	15.95	18.17	65.88

The ash or inorganic matter, varying greatly in quantity, was still further subjected to analysis, with the subjoined result:—

Peat ash.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silica	49.09	65.39	58.31	88.95	59.37	61.32
Potassa	.63	.57	.41	.12	.14	.55
Soda	.37	.31	.18	.11	.08	.23
Lime	13.87	10.60	14.18	1.43	18.10	12.44
Magnesia	3.01	2.24	2.90	.82	1.41	2.43
Iron and alumina	14.92	6.31	10.21	7.04	6.58	9.71
Sulphuric acid	8.23	8.34	2.11	.12	.14	2.37
Carbonic acid	10.27	5.97	11.63	1.82	14.12	10.69
Phosphoric acid	Trace.	Trace.	....	....	....	....
Chlorine	....	....	Trace.	....	....	Trace.
	100.39	99.73	99.70	100.70	99.94	99.96

The following is the elementary analysis of the organic matter :—

	Per 100 of the organic matter.			Per 100 of the original air-dry peat.		
	Carbon.	Hydrogen.	Oxygen & nitrogen.	Carbon.	Hydrogen.	Oxygen & nitrogen.
Peat No. 1..........	53.06	6.19	40.75	39.03	4.56	29.93
Peat No. 2..........	52.22	6.11	41.67	34.30	4.01	27.37
Peat No. 3..........	52.02	6.68	41.30	35.30	4.54	27.99
Peat No. 4.........	48.66	9.73	41.61	11.19	2.24	9.57
Peat No. 5..........	46.58	10.51	42.91	6.44	1.45	5.93
Peat No. 6..........	51.94	6.17	41.89	34.22	4.06	27.60

The composition of the above samples of peat compared with that of *hard wood* is as follows ;

	Carbon.	Hydrogen	Oxygen and nitrogen.	Ash.	Water.
Wood.............	39.6	4.8	34.8	0.8	20.0
Peat No. 1.........	39.03	4.56	29.93	12.73	13.75
Peat No. 2.........	34.30	4.01	27.37	21.67	12.65
Peat No. 3..	35.30	4.54	27.99	18.17	14.00
Peat No. 4	11.19	2.24	9.57	67.17	9.83
Peat No. 5..	6.44	1.45	5.93	77.35	8.83
Peat No. 6.........	34.22	4.06	27.60	18.17	15.95

The heating power of each of the six samples of peat, as compared with an equal weight of air-dry oak wood, is based on the amount of oxygen required for complete combustion, or by the number of pounds of water raised from 32° to 212° F.

100 lbs. of air-dry peat No. 1 = 104.2 lbs. of oak wood.
100 lbs. of air-dry peat No. 2 = 94.7 lbs. of oak wood.
100 lbs. of air-dry peat No. 3 = 98.1 lbs. of oak wood.
100 lbs. of air-dry peat No. 4 = 34.4 lbs. of oak wood.
100 lbs. of air-dry peat No. 5 = 16.9 lbs. of oak wood.
100 lbs. of air-dry peat No. 6 = 89.6 lbs. of oak wood.

All of which is most respectfully submitted.

P. B. ROSE,
Asst. in chemistry, University of Michigan.

Chemical laboratory, University of Mich., Nov. 22, 1873.

(e) *Peat analyses by Prof. Peckham.*

Prof. N. H. Winchell, state geologist of Minnesota:

MY DEAR SIR —The following is a report of the chemical investigations conducted in accordance with your suggestions for the geological survey of Minnesota:

I desire to state that when I assumed the duties of chemist to the geological survey last August, I found absolutely nothing in the University laboratory in preparation for special investigations of the nature of those I was about to undertake. The room in which I have worked had to be fitted up. Much of the apparatus used had to be procured from New York. All my solutions of reagents had to be prepared, as well as many of the reagents themselves. In fact I began at the beginning and fitted up my laboratory before doing any of the work at hand. I have also discharged at the same time the duties of a full professorship in the University, and have consequently only been able to give the work of the survey the second place.

No. 1. *Tripoli.*—You have placed in my hands for examination a specimen of tripoli, or very fine grained, friable sandstone, of which 25.15 per cent. was found to be soluble in boiling concentrated hydrocholic acid. The remaining 74.85 per cent. consisted of microscopic, apparently angular fragments of white quartz. The soluble portion consisted chiefly of ferric oxide (Fe_2O_3) and a smaller portion of the carbonates of lime and magnesia, of which quantitative determinations were not made.

"A," clippings of native copper.—A specimen which I have marked A, of which I have made the following record: A letter was handed me addressed to Prof. Winchell by R. S. Russell, of Pleasant Grove, Olmsted Co., Minn., containing an enclosure of minute fragments or clippings of what appeared to be native copper. "Found on the south bank of Root river in the neighborhood of green shale * * imbedded in loose rock found on the surface."

Completely soluble in dilute nitric acid. Evaporated to dryness the residue was completely soluble in water and contained nothing but nitrate of copper.

Mineral Water.- A pint of mineral water not labeled. It appeared not to have been filtered. The results of as complete a qualitative analysis as the small quanity would admit of, are as follows:

The water contained a brown, flocculent deposit and crys-

talline scales. It was neutral to litmus, tumeric and lead papers, showing the absence of free acids, alkalies and sulphuretted hydrogen. It was also odorless, with a bitter saline taste.

Three hundred and ninety-three cubic centimeters were evaporated to dryness, A portion of the residue dissolved in water contained potassium, sodium, chlorine, sulphuric acid and a trace of phosphoric acid. The residue insoluble in water dissolved in hydrochloric acid with escape of carbonic acid, and the solution contained chlorides of lime and magnesia.

The results indicate that the water held in solution:

Carbonate of lime.

Carbonate of magnesia.

Chloride of sodium and potassium.

Sulphate of sodium and potassium.

Phosphates, a trace.

A little organic matter was not dissolved in hydrochloric acid.

This water will be further examined.

No. 29.—A specimen supposed to be carbonate of magnesia, was found to be a light-colored friable clay, containing a large proportion of sand; will be still further examined.

Nos. 30 *and* 31.—Two specimens of siliceous limestone, containing small, rounded grains of a soft, light-green mineral, were to be examined for carbonate of copper. Dilute hydrochloric acid dissolved the lime with disengagement of carbonic acid. The hydrochloric acid solution was colorless and contained lime, iron, magnesia and a trace of manganese, with carbonic and silicic acids, but no copper. The insoluble portion consisted of grains of quartz sand, and the green mineral which contained iron, alumina, magnesia and soda, with silicic acid. This green mineral has the appearance of being green slate, in water-worn grains. The species can only be accurately determined by a quantitative analysis. They will be still further examined.

Peats numbered 16 *to* 28 *inclusive.*—Thirteen specimens of peat were examined with reference to hygroscopic water, organic matter and ash. They were all treated exactly alike. An average sample of each of the specimens was finely pulverized and thoroughly mixed Of this one gramme was carefully weighed in a one-ounce platinum crucible. The covered crucible containing the assay was then placed in an air bath, and heated to 212-220 degs. Fahr., until it

ceased to lose weight. The loss was estimated as hygroscopic water. The cover was then removed, the crucible inclined and heated to dull redness, finally to bright redness, until the combustible matter was entirely consumed. The loss was estimated as organic matter and the residue as ash. The following results were obtained:

No.	Hygroscopic water.	Organic matter.	Ash.
16	12.72	68.52	18.76
17	13.04	48.64	38.32
18	10.99	44.56	44.45
19	20.64	53.60	25.76
20	16.75	47.03	36.28
21	11.93	33.48	54.59
22	13.58	53.28	33.14
23	11.03	41.67	47.30
24	10.225	64.475	25.30
25	10.80	16.33	72.87
26	8.69	31.90	59.41
27	9.85	42.63	47.52
28	29.44	58.17	12.39

These peats will be still further examined.

An absolutely accurate comparison of these peats with oak wood cannot be made without a determination of the carbon and hydrogen present in each; but in order to furnish a tolerably correct basis of comparison, the average amount of carbon and hydrogen as compared with the total amount of organic matter, was estimated in the six specimens examined by Dr. Rose. It was found to be 58.4 per cent. The proportion contained in oak wood being made the standard of comparison or 100 per cent., all of the peats examined by Dr. Rose and myself, were found to possess the following values, 100 pounds of the air-dry substance being taken in each case:

100 lbs.	Oak wood	100.0 lbs.	100 lbs.	No. 19	70.5 lbs.
" "	Serial No. 5	99.0 "	" "	" 20	61.7 "
" "	" " 6	86.0 "	" "	" 21	44.0 "
" "	" " 7	89.3 "	" "	" 22	70.1 "
" "	" " 8	30.2 "	" "	" 23	54.8 "
" "	" " 9	18.1 "	" "	" 24	84.9 "
" "	" " 10	86.7 "	" "	" 25	21.4 "
" "	" " 16	90.2 "	" "	" 26	42.0 "
" "	" " 17	64.0 "	" "	" 27	56.1 "
" "	" " 18	58.6 "	" "	" 28	76.5 "

No. 28 was one of the first examined, and was not probably sufficiently dried, as the amount of water is very large, 29.44 per cent. The ash is only 12.39 per cent., however, which is very low. This peat is no doubt very nearly as valuable as number 16, when properly dried.

The value of these peats as compared with each other, is as follows:

1	Ser. No. 5	7	Ser. No. 28	13	Ser. No. 27
2	" 16	8	" 19	14	" 23
3	" 7	9	" 22	15	" 21
4	" 10	10	" 17	16	" 26
5	" 6	11	" 20	17	" 8
6	" 24	12	" 18	18	" 25
				19	" 9

All of which is respectfully submitted.

S. F. PECKHAM,
Chemist to the geological survey of Minnesota.

St. Anthony Falls, Dec. 23, 1873.

Of the foregoing samples analyzed by Prof. Peckham,

No. 1 was obtained at Stillwater, Washington county.

"A" was from Pleasant Grove, Olmsted county.

"Mineral water" was from the reputed salt springs at Belle Plaine, Scott county. Other samples have been since obtained and will receive analysis.

No. 29 was from the sandstone near the Red Jacket mills, in Blue Earth county, apparently consisting of magnesia or magnesia and lime. (See description of that locality, page 96.)

Nos. 30 and 31 were from the St. Lawrence limestone, the former from St. Lawrence, Scott county; the latter from Judson, in Blue Earth county.

No. 16 was a peat from St. Cloud, 18 inches below the surface.

No. 17 was a peat from Lura, in Faribault county, 18 inches below the surface; land of W. Z. Haight. Bog A.

No. 18 was from the same bog as No. 17, 3 feet below the surface.

No. 19 was a peat from the same place, Bog B, 18 in. below the surface.

No. 20 was from the same bog as No. 19, 3 feet below the surface.

No. 21 was a turf-peat, owned by John Haggard, sec. 4, T. 101, R. 39.

No. 22 was from K. K. Peck's land, near Windom, 2 feet below the surface.

No. 23 was from K. K. Peck's land, near Windom, 3 feet below the surface.

No. 24 was a peat from land of Rev. Edward Savage, near Windom, 18 inches below the surface.

No. 25 was a turf-peat from S. O. Taggart's land, sec. 24, T. 105, R. 35.

No. 26 was a peat from land of A. A. Soule, Mountain Lake, 2 feet below the surface

No. 27 was peat from land of St. Paul & Sioux City railroad, sec. 13, T. 106, R. 37, 2 feet below the surface.

No. 28 was a peat from land of F. G. Taylor, Brooklyn, Hennepin Co.

(f) *Where peat exists in Minnesota.*

The method adopted for testing for peat is very simple. A common augur, of about one and a half inch bore, is supplied with a jointed rod eight or ten feet in length. The handle and all of the joints are removable, and can be transported in one package. The thread of the auger will bring out the material passed through, from any desired depth, the samples being preserved if necessary. This will answer for most cases. If the peat prove too pulpy or too wet to be brought out on the thread of the auger, other means must be adopted. When it is too fibrous and loose to be penetrated by the auger, the desired sample can be taken out by the hand, as the loose and fibrous parts are always near the surface. The best way to illustrate the contents of a peat marsh, is to take out and dry a full section from the surface to the bottom, cutting the fiber with the slane, and exposing the variations in composition and color without disarranging their superposition.

The following notes on the observed location of peat de posits do not embrace a much larger class of observations, made during the summer on localities where peat does not exist, but where it was supposed by the owners to exist in abundance

1. At a point about half a mile east of Empire City, in Dakota county, the augur was sunk in the land of Albert Whittier. This is within the valley of the Vermilion river, and revealed the following section.

No. 1.—Turf peat, about	1 ft.
No. 2.—Black, sticky, heavy mud	3 ft.
No. 3—Sand, with some gravel, penetrated	1 ft.

This character of surface prevails, judging from outward appearances, over an area of many acres in this part of the valley, passing also on to the land of Mr. Gray, further east.

2. Sec. 22, T. 114, R. 19, Dakota county. Owner's name unknown. Agents, Claggett & Crosby, Farmington.

No. 1.—Wet turf-peat	1 ft.
No. 2.—Fine, black mud	2 ft.
No. 3.—Green, sandy clay	1 ft.
No. 4.—Sand, of a greenish cast	2 ft. 4 in.
No. 5.—The same, indefinitely.	

3. About sec. 22, T. 114, R. 19, Dakota county.

No. 1.—Black turf-peat, loose and fibrous.................... 1 ft.
No. 2.—Fine, black mud.................................. 6 in.
No. 3.—Sand and gravel.................................. 6 in.
No. 4.—The same indefinitely.

4. In the same bog; near an outcrop of the St. Peter, N. W. from Empire City.

No. 1.—Black turf, fibrous.................................. 1 ft.
No. 2.—Sand; the same indefinitely...................... 1 ft.

5. In the same bog; owned here by James Murphy.

No. 1.—Black, impure turfy peat.......................... 1 ft.
No. 2.—Yellowish-green, sandy clay...................... 1 ft.

This burned over more or less for some distance in various directions a few years ago, passing also on to the land of others. This whole slough is termed "meadow" by the owners, and furnishes annual crops of hay. In the dry months teams can be driven over it in most places. It is in the valley of the Vermilion, the greatest part lying on the north side of the river.

6. Land of James Murphy, sec. 15, T. 114, R. 19.

No. 1.—Turf-mold, or Turf-peat and hard enough for teams to pass over, little fibrous, burned over a few years ago.. 1 ft. 6 in.
No. 2.—Yellowish-green clay [see Dr. Roses analyses] 6 in.

7. Near the center of the same bog, E. of Murphy's.

No. 2—Black turf-peat, wet.............................. 6 in.
No. 2.—Clay and mud of brownish-ash color, with streaks of green.. 1 ft.

8. Land of Caleb Adams, same slough. One mile northwest of Empire City.

No. 1.—Fibrous turf-peat.......................... ......1 ft. 6 in.
No. 2.—Sand, indefinitely.

This peat has as good (or better) appearance as any yet seen on this marsh.

9. Land of D. S. Pilcher, two and a half miles east of Farmington, sec. 27, T. 114, R. 19. A branch of the Vermilion valley, coming in from the southwest, consists now of a long, wide slough, having the surface characteristics of the valley of the Vermilion.

No. 1.—Black muck, somewhat fibrous on the top, becoming clayey and sandy, but passing into stiff, brown clay in 18 in...... 1 ft.

Tested no further.

Mr. Pitcher says this surface turf burned, in 1863, from July to December, making many "hog-wallows."

10. Kasota, LeSueur County. This marsh is crossed by the Sioux City R. R. This point is on the east side of the R. R., six rods from the drift bluff.

No. 1.—Pretty good peat		8 in.
No. 2.—Black, sandy clay........	2 ft.	

The whole depth drilled showed frequent shells.

11. In the same marsh, on the west side of the R. R., fifteen rods from the drift bank.

No. 1.—Roots and stems of grass, with some peaty, vegetable decomposition........		8 in.
No. 2.—Black, peaty mud, with a few fragments of shells and some sand........	1 ft.	4 in.
No. 3.—Black or brown mud, with sand and fragments of shells........	4 ft.	

12. Head of lake Emily, in LeSueur county, near St. Peter. Land of M. French.

No. 1.—Roots and soft, fibrous lake sediment....	1 ft.	
No. 2.—Peaty lake sediment, with little or no sand....... [See Dr. Rose's analyses.]	1 ft.	6 in.
No. 3.—Peaty mud, with a little sand...	1 ft.	
No. 4.—Black, lake mud, sandy........	2 ft.	

13. Wells, Faribault Co., land of Clark W. Thompson.

No. 1.—Watery, fibrous peat........	4 ft.	
No. 2.—Peaty mud, with shells and some sand........		6 in.
No. 3.—Brownish mud and clay........		6 in.

14. Wells, Faribault Co., land of Clark W. Thompson. Same slough as the last.

No. 1.—Good peat, showing some sand grains........	6 ft.	
No. 2.—Peaty mud and clay. [See Dr. Rose's analyses]....	6 in. to 1 ft	

15. Wells, Faribault Co., same slough.

No. 1.—Peat of good quality........ ...	5 ft.	
No. 2.—Peaty mud........		6 in.

16. There is a peat deposit of 80 or 100 acres near Lura, in Faribault county, sec. 30, T. 104, R. 25. Land of H. F. Quinby and J. Robinson. Said to be four feet deep.

17. Peat is manufactured near Fairmount, in Martin county, by Mr. A. L. Ward.

18. Near Lura station, in Faribault county, peat exists in considerable quantities, on land of W. Z. Haight. [See Prof. Peckham's analyses.]

19. Sec. 24, T. 105, R. 35; Cottonwood county. Land of S. O. Taggart. In a dry slough, covering many acres, the surface consists of a turf-peat, to the depth of about a foot, passing into black mud and sand. The very top is fibrous and even spongy.

20. Land of S. O. Taggart, 5 miles east of Windom. In a narrow spring ravine, where water stands or slowly runs throughout the year, and near its head, a thickness of a foot or more of turf-peat may be taken out over a space of a few rods square. It is thicker and better near the head of the ravine than at any other point, owing to the more constant protection of the grass and roots from the prairie fires.

21. Other similar peaty ravines occur on land of Miss Ellen Imus, near that of Mr. Taggart.

22. A mile and a half northeast of Cannon City, Rice county. Land of Wm. Dunn. A shaking bog of peat is said to occur on S. E. 1-4 sec. 11. T. 110, R. 20.

23. Mountain lake, Cottonwood Co. Near Mountain Lake station, on land of A. A. Soule, a coarse turf-peat covers the surface of a dry slough to the depth of ten to eighteen inches. Near a spring along side of this slough which is tributary to Mountain lake the surface quakes, and the peat is thickest.

24. Around Mountain lake the land is low, and is flooded in the wet season. This low land contains considerable peat for some distance out toward the lake. The surface shakes under the tread. It is covered in the summer with a tall grass, which much resembles the wild rice, yet the softest places, where the peat occurs purest, are furnished with a short grass. Peat here is two or more feet thick. The land examined is owned by A. A. Soule.

[See Prof. Peckham's analyses.]

25. Sec. 13, T. 106, R. 37, Amo, Cottonwood Co. A slough that shakes is in the valley that forms the prolongation of the Des Moines valley northwestward above the great bend a few miles above Windom, and has a spongy

peat about two feet in thickness, with black mud below. It covers six or ten acres.

26. In the same prolongation of the Des Moines valley, on K. K. Peck's land, two miles above the bend of the Des Moines, is a thickness of two or three feet of peat. This valley seems to hold about two feet of peat along a considerable area through the middle, and would supply a great quantity. It is not of a superior quality, but might be very useful to the settlers.

27. Sec. 2, T. 105, R. 38, Cottonwood Co., Government land. Side-hill peat occurs on a gentle slope over the space of a few rods, having a thickness of a foot and a half or two feet. Such peatty patches appear also on the opposite side of the main valley, arising from the issuing of springs that keep the surface moist, while the lower land in the same slough is dry and hard. This peat is not free from sand. It also smells strongly of sulphuretted hydrogen.

28. NE ¼ sec. 28, T. 105, R. 36, Cottonwood Co. Land of A. J. Hall. In a turfed ravine, where water stands or slowly oozes through the turf, sloping gently toward the Des Moines river, a turf peat may be taken out to the depth of a foot or twenty inches. The belt containing peat is from ten to twenty feet wide, and similar in its situation to that of Mr. S. O. Taggart, but more extensive. It shakes under the feet for three or four feet about, but a horse can walk safely over it in most places in the dry season. Indeed, it is mown for hay every year. An irony scum lies on the ground and on the grass stalks. The peat itself is a turf, but contains shells and some grit.

Another similar ravine is on the same claim. Numerous others might be located along the ravines that cross the Des Moines bluffs.

29. SW. ¼ sec. 4, T. 104, R. 36. Delafield, Jackson county. Land of Rev. Edward Savage. A good moss peat occurs here in a slough, having an average thickness of two feet, over an area of ten acres or more. The slough is confined between bluffs that appear to be entirely composed of drift, and has a feeble drainage into a small lake (String lakes). The surface is mostly covered with a short (blue joint?) grass, but also with chair-bottom rushes. Some patches also of *Typha latifolia* are seen. No horse tail rush appears. In passing over the surface of this marsh it quakes five or six feet around, and the auger hole is immediately filled with water to the top. Below eighteen inches (even sparingly in ten or twelve inches) shells begin to be rather

common, and the auger next brings up a black mud with many shells. The most of this peat is made up of the peat moss, though at a depth of a foot or eighteen inches it contains grass roots and other fiber.

30. NE. ¼ sec. 30, T. 105, R. 36. Land of Arthur Johnson. Turf-peat occurs in a ravine, twenty feet over, where fuel can be taken out.

31. Land of Geo. C. Bush, sec. 6, T. 105, R. 37, holds a peatty turf, in a dry slough near the mouth of a ravine, in considerable abundance. Sandy below.

32. T. 105, R. 38, Southbrook, Cottonwood county. Peat exists, according to Mr. John Crapsey, three miles north of Talcott lake.

33. Land of the St. Paul & Sioux City and Sioux City & St. Paul R. R., sec. 31, T. 105, R. 37, Jackson county. A thin deposit of about six inches of peat covers about half an acre, mostly under water. This is the only peat that can be found in the vicinity of Heron lake.

34. Land of F. G. Taylor, Brooklyn, Hennepin county, seven miles north of Minneapolis, furnishes a fine quality of peat. [See analyses of Prof. Peckham.]

35. Land of B. S. Langdon, sec. 4, T. 102, R. 41, Nobles county. Here a turf-peat occurs, about 14 inches in thickness, lying on a side-hill or gentle slope, having a springy character when trod on. It is underlain by a black mud, which has been mistaken for non-fibrous peat. Of the turf several cords (perhaps a hundred) have been taken off, preparatory to excavating the rich (?) peat below, when it was discovered that it would not burn, but when placed in the fire turned out hard and heavy like burned clay. The turf itself will make a fuel that will compare well with any turf-peat discovered.

36. Peat, eight or ten inches thick, exists on the railroad land, sec. 27, T. 101, R. 40, Nobles county, of a turfy character, but good quality. It lies over an acre or two, but may be taken out probably in other places along the different creeks that unite here.

37. At Bigelow, in Nobles county, there is a considerable thickness, perhaps two feet, of half-carbonized, pulpy, vegetable silt, lying entirely below the water of a lake, made up of decaying sedges and grasses and their roots. It is torn in pieces by the waves in the lake and gathers about the shores and under the bog-turf, driven most abundantly to the side that faces the prevailing winds. It is often intermixed with fine mud and shells, especially near the

bottom. It will probably furnish, if dry, a combustible material that would answer well for fuel, if it should prove obtainable in sufficient quantities, and especially if it were to be pressed and molded. It has not the necessary origin nor nature to be styled peat.

38. John Haggard takes out turf in a low patch on sec. 4, T. 101, R. 39, Nobles county. It occurs partly on state swamp land, partly on railroad land, and partly on the claim of Charles Peterson. It is in nature and position similar to the turf on B. S. Langdon's land, northwest of Worthington. Mr. Haggard takes it out with a spade, about a foot in depth, in large blocks. Then drawing it to the house he cuts it into convenient smaller blocks, and spreads and piles it for drying. After drying about four or six weeks it is fit for burning. It burns quickly but leaves considerable ash. (See the report of Prof. S. F. Peckham.)

39. On the S. E. ¼ sec. 27, T. 102, R. 34, Jackson county, Mr. W. V. King correctly describes a peat marsh.

40. Peat occurs of good quality just west of the limits of St. Cloud, in Stearns county, about a foot and a half thick, underlain by a bed of shell marl, which, before the introduction of the Shakopee lime, was considerably burned for quick lime. [See Prof. Peckham's analyses.]

41. Peat occurs within the corporate limits of St. Paul, having, according to Dr. C. D. Williams, a depth of eight feet. It lies on the land of Mr. Schmidt. [See analyses of Dr. Rose.]

42. At Red Wing, Goodhue county, good peat has been taken out and experiments in manufacture made on the farm of Capt. O. Eames. This peat lies in the bottoms, between the shore and next range of river bluffs. The experiments were made under the direction of the *Davidson steamboat company*, by Capt. Isaac Webb, of Stillwater.

43. At East Minneapolis, Mr. W. W. Wales and Dr. M. D. Stoneman took out about 25 cords of peat in 1865. The average thickness is about eight feet, and the peat, although light and fibrous at the top, was heavy and solid below, becoming brown or nearly black. Digging and drying cost 80 cents per cord. It was consumed in common stoves, leaving a heavy ash. In cost it would not compete with pine wood from the saw mills.

(g) *The working of peat.*

The great porosity and consequent bulk of peat make it exceedingly desirable that, before it is used for fuel, it should be compressed, both for the purpose of removing the contained moisture, and of getting an intenser heat. The brown, fibrous peats are also liable to crumble on being handled, and will not bear transportion, unless rendered more tenacious and dense by some process of manufacture.

To accomplish this, various methods have been invented. The "turf" that is extensively burned by the peasantry in Ireland, France and Germany, is simply taken from the bog and dried in the sun. When first taken from the bog its weight consists of from 70 to 90 per cent. of water. When ready for use it still holds from 20 to 35 per cent. That which has been stacked from six to twelve months still retains from 18 to 20 per cent., and after being kept in a dry house for two years, from 10 to 15 per cent. of water. Its heating effect then is about equal to that of an equal weight of pine wood. Peat may be condensed and prepared by machinery so as to weigh more than hard wood. It may be made nearly as solid and tenacious as coal, its specific gravity being nearly that of bituminous coal. In this form it may be subjected to a strong blast, rendering it useful in ordinary grates and furnaces.

It is intended to describe briefly some of the methods of manufacturing peat in America. Many of the facts herein stated are obtained from *Leavitt's peat journal* of March, 1867; others from Prof. Johnson's "*Peat and its uses.*"

"In this country comparatively little has been done; and until quite recently, no machinery whatever, especially constructed and adapted for the production of solid fuel from peat, has been put in practical operation. The impression has seemed to prevail that the material is to be treated like clay, and that brick machines might be readily made to work the desired results; but the idea is erroneous. Numerous brick machines have been tried, some of them very ingeniously and perfectly constructed, and which have been demonstrated to be also perfect in their operation upon clay; but have proved an entire failure when peat was substituted instead. It is true, however, that with two or three of these machines peat has been compressed into compact blocks having the appearance of great solidity *when moist;* but so soon as the moisture is evaporated, as it will inevitably be in time, the mass is found to be porous and light.

"Quite a number of *presses*, some of them exceedingly ingenious in device and construction, and powerful in their operation and supposed to be so arranged as to press the water out of the mass, and leave the material compact and nearly or quite dry, have been built and tested, with failure of success as a uniform result; and although the records and reports of such cases, both in Europe and this country, are sufficiently extensive to explode the idea that any profitable results can be obtained by pressure alone, there are, nevertheless, those who are still persistent in their efforts to accomplish it by such means, and are now devising new methods of applying powerful pressure, which, were they to consider but for a moment the nature of the material in its crude state, would be seen at once to be clearly of no avail. The famous Beater press, which, within a few years, has acquired great notoriety, and is now probably the most powerful press in use for hay, straw, cotton, tobacco, &c., has been tried several times in New York and Massachusetts, by parties sanguine of success, but with only the same results as with other presses."

Ashcroft and Betteley's process.—"Under the patents of Ashcroft and Betteley operations were commenced in Massachusetts in 1864. Their process, as claimed, provides for separating the fibrous from the thoroughly decomposed portions of the peat, by combing; in doing which the mass is reduced to a pulp, which is then conveyed into high tanks where it is proposed to allow it to remain until by its own weight and pressure it shall have become sufficiently dense to be formed into blocks, when, by opening a small gate near the bottom of the tank, it is presumed that the pressure of the superincumbent mass will force it out in a continuous sheet, of uniform size, as regulated by the orifice, which may then be cut in blocks and laid away to dry."

Roberts' process.—The machinery set up at Pekin, New York, in 1865, is the invention of Mr. M. S. Roberts. The following description of it is from the *Buffalo Express*, of November 17, 1865: "In outward form the machine was like a small frame house on wheels, supposing the smoke-stack to be a chimney. The engine and boiler are of a locomotive style, the engine being of thirteen horse power. The principal features of the machine are a revolving elevator and a conveyor. The elevator is seventy-five feet long, and runs from the top of the machine to the ground where the peat is dug up, placed on the elevator, carried to the top of the machine, and dropped into a revolving wheel that

cuts it up, separates from it all the coarse particles, bits of sticks, stones, etc., and throws them to one side. The peat is next dropped into a box below, where water is passed in sufficient to bring it to the consistency of mortar. By means of a slide under the control of the engineer, it is next sent to the rear of the machine, where the conveyor, one hundred feet long, takes it and carries it to within two rods of the end; at which point the peat begins to drop through to the ground to the depth of about four or five inches. When sufficient has passed through to cover the ground to the end of the conveyor—two rods—the conveyor is swung round about two feet, and the same process gone through as fast as the ground under the elevator, for the distance of two rods in length, and two feet in width, gets covered, the elevator being moved. After the eighteen rods are covered, the machine is moved two rods ahead, enabling it to again spread a semi-circular space of some thirty-two feet in width by eighteen rods in length. The same power which drives the engine moves the machine. It is estimated by Mr. Roberts that by the use of this machine from twenty to thirty tons of peat can be turned out in a day." Four men are required to run it.

In this process it is to be observed that the method requires the addition of a very considerable quantity of water, before the peat can be treated; whereas a great desideratum has ever been to discover some process by which the large amount of water the peat already contains in its natural state may be discharged.

Hodges' process.—Mr. James Hodges, of Montreal, after considering the many difficulties in the way of manufacturing peat successfully, conceived the idea of a manufactory complete, which might be made to float about in the bog, excavating, pulping, manufacturing and spreading out the pulped peat to dry, until some seventy per cent. was evaporated, or it was fit for carriage to the store or to market. After three years' experience, he arrived at the conclusion that it may be effected in the following manner:

"An extensive, undrained bog, from eight to twelve feet in depth—or if deeper the better—have been selected, the first process is to trace out at some distance from the margin, a contour level line of say several miles in extent. Along this line, a space of some nineteen feet in width must be cleared and the live moss or turf entirely removed; by the side of this a space of ninety feet in width is to be cleared and drained to receive the pulped peat.

"At one end of the contour line before mentioned, a barge or scow, eighty feet long, sixteen feet beam and six feet deep, must be constructed, and launched into a hole in the bog dug to receive her. The barge or scow is to contain all the machinery necessary for the complete manufacture of the peat.

"At one end of the scow is placed a pair of large screw augers, eleven feet in diameter, which, being provided with proper shafting and gearing, are made to revolve by means of a steam engine placed on the rear of the vessel. These augers, or screw excavators, bore out the peat in precisely the same manner that a common auger bores itself into wood; and, the scow being made to move onward as the boring proceeds, it follows that a channel nineteen feet wide, of from four to six feet deep is formed, in which the scow, with her burden of machinery, floats, the water from the adjacent peat draining into and filling the canal as fast as it is made, the usual speed of the scow being some fifteen feet per hour.

"A competent engineer should determine and lay out the canal level, as well as arrange its water supply, upon which depends in a great measure the successful working of the whole.

"The peat, when bored out or excavated by the screws, is delivered into the barge, and conveyed by means of an elevator to a hopper, into which it is tumbled. It then passes through machinery which removes all sticks and roots, and, eventually destroying the fiber, reduces the peat to a homogeneous mass of soft pulp, like well tempered mortar.

"This pulp then passes into a long spout or distributor, which, extending at right angles over the side of the scow, spreads out the pulp on the leveled moss by the side of the canal in a thin slab nine inches in thickness and ninety feet in width.

"After the slab or pulp has been deposited for a couple of days, or in hot weather for a shorter period, it begins to consolidate, and shows symptoms of cracking. Immediately any cracks make their appearance, it must be marked out by drawing a frame work carrying curved knives placed six inches apart across it. A few days more harden the pulp so that by the aid of boards a man can walk on it, and mark it longitudinally with cuts eighteen inches apart.

"In about a fortnight, the shrinkage of the pulp-slab causes the cuts made in it to open, and the whole presents

the appearance of an immense floor covered with bricks eighteen inches long by six inches wide. As soon as the bricks are sufficiently hard to bear handling, they are separated and "footed;" that is, stood up on the ends, five in a stook, with one across the top, in which position they remain until dry enough to be removed to the store or to the market.

"In the manufacture of peat fuel considerable experience is required, and unless attention is paid to matters of detail, apparently of little importance, serious loss may be the result.

"In forming, or uncovering the canal track, nothing more is required than that the turf, or live moss, about six inches in thickness, together with the roots of all trees upon the surface of the bog, should be removed; and as upon all undrained bogs the roots of such stunted trees as grow there are all on the surface, this operation is easily accomplished.

"In the preparation of the pulp-beds great care is required, and a surface should be obtained as level and even as possible. The roots of all trees must be removed, and this is more readily accomplished with the trees themselves, by which means considerable labor is saved, one man pulling them down on one side, while another with an ax cuts the lateral roots at some distance from the stem, leaving the smaller portions behind. The long grass, shrubs and rank mosses are cut down with a short scythe, and used in filling up any irregularities in the surface. Drains from nine to twelve inches deep should also be cut and covered over with the spare turf taken from the canal track. The soil from the drains may also be used in leveling and filling up inequalities in the pulp-bed. In some places, where the growth of shrubs has been very rank and coarse, the turf upon the whole surface of the pulp-beds has been cut into strips and inverted; but it is better to cut drains, and leave the turf in its natural position. The soft pulp, when poured upon it in a semi-fluid state, advances lava like, pressing down any small branches of shrubs and the long grasses which may be standing in the way of its onward progress.

"The pulp should not be deposited nearer than five feet of the canal, and upon this space may be placed any surplus moss or turf from the uncovering of the canal track, which will not only keep the pulp in place, but also form a road and towing path for the canal. At the rear, or ninety feet

from this bank, a double thickness of turf is all that is necessary to complete the pulp-beds.

"The canal track and pulp-beds being prepared, and the scow with its machinery in position, nothing more is required than to set it in motion, giving the necessary feed, say one and a half inches for each revolution of the screw excavators, which may be increased to three inches if necessary. As the screws revolve, they cut off continuous slices of the peat, which, by the assistance of a couple of men, are delivered, through the rear of the shield the screws work in, into a well in the bow of the scow. These men also remove any large masses of extraneous material, such as pieces of wood, roots of trees, etc., which may work in. It is sometimes required, when working in peat which is very full of roots, to have a man placed in front to remove them as they are brought up by the knives of the screws—roots as much as a man can lift being occasionally excavated.

"After the peat is delivered into the well, it is carried by means of an elevator, and tumbled into a hopper, from which it passes through the stick and fiber catcher, the pulping and distributing trough, without any assistance whatever; it being only necessary to see that the stick catcher is kept clear, and, occasionally, when the pulp is too dry, to turn on a pump until it is reduced to a proper consistency.

"The leveling of the pulp should be done as evenly and smoothly as possible. A few days' experience will enable any intelligent man to accomplish this; and upon its being well done depends, in some measure, the quality of skin upon the peat—so essential, not only in shedding the rain and preventing cracking from the sun, but also in giving a permanent toughness to the bricks.

"The crew of the scow, all told, will number six, including the master who keeps the knives of the screw excavators clean, and sees that all is going on right; two men at the screw excavators, one engine man, one man leveling the pulp, and one man to tend the stick-catcher and pulping-spout.

"The marking of the pulp-beds into transverse cuts, at six inch intervals, is proceeded with as soon as the pulp begins to set, or becomes so tough that when the incisions or cuts are made in it by the knives, they do not re-unite. The operation is performed by two men, one on each side of the pulp-bed, who by means of a rope pull a frame-work of wood, carrying curved knives to and fro across the bed. A

little practice enables them to perform the work with great accuracy. The longitudinal cuts, eighteen inches apart, are made as soon as the pulp is sufficiently hard to bear the weight of a man upon a plank laid on its surface. It is performed by pushing a circular plate of iron, which, cutting like a circular saw, severs the peat to the very bottom. In making these last cuts, care should be taken that they go quite through the peat, so that surface water from rain may freely pass off through the drains in the pulp-beds into the canal.

"Upon the state of the weather depends the time when the next operation should be performed; but if the pulp-slab, when first spread out, is not more than nine inches in thickness, which it should never exceed, then a fortnight will be ample time to harden the bricks for footing.

"The footing is done by gangs of men and boys, one man and three boys working together; the man, using a suitable tool, separates the bricks, which the boys foot, or place in groups or stooks of five; four stand on their ends inclining to each other, with their tops touching, the fifth being balanced horizontally upon them. A man and three boys will foot four thousand bricks in a day.

"After the bricks have been exposed to the weather for a few days, they should be refooted or turned, two boys handling four thousand as a day's work.

"Nothing now remains to be done but to wheel the bricks, when sufficiently dry, into barges, and convey them to the store."

Mr. Hodges' plan of operation is rather extensive, not to say immense, yet wherever the necessary area and supply of peat can be found, there can be no doubt but his method would prove as profitable as any other, and perhaps more so. It has been put into successful operation in Canada, and has furnished a fuel that, used on the Grand Trunk railway, produced the most promising results.

Elsberg's process.— This was invented by Dr. Louis Elsberg, of New York city, in 1864, and his experimental machinery was erected at Belleville, N. J. It is based on the principle of the *Exter process*, an invention made in Bavaria, in 1856. In the latter method the bog is laid dry by drains, and the bushes and grass turf removed down to good peat. A gang of three plows is then propelled by a portable steam engine over the surface tearing up the peat to the depth of about an inch. It is then pulverized where it lies by a harrow, drawn by oxen. After several turnings

by an instrument like our cultivator, in order to expose it to the air and sun, it is gathered by scrapers and loaded in wagons, and conveyed to the press or magazine, where it is further pulverized by passing it through a series of toothed rollers. It then enters a very complicated drying oven, where by a series of spiral rollers it is moved over successive shelves or floors, the interior of the oven being heated partly by steam and partly by hot air. The floors consist of steam-chambers, made of iron, and the hot air made to circulate over the peat at a temperature of 120° to 140° Fah. The fine peat is thence conveyed to the press which forms it into bricks of suitable size for locomotives. It has a specific gravity of 1.14, and forms an excellent fuel. One cubic foot of this pressed peat weighs 72 pounds. The process of Elsberg varies from this in having a cylindrical pug-mill in which the peat, air-dried as in Exter's process, is further broken, and at the same time subjected to a current of steam admitted through a pipe and jacket surrounding the cylinder. The steam peat is then condensed by presses similar to those of the Exter method, fed directly from the mill. In this way the complicated drying-oven of Exter is dispensed with. Samples of peat prepared by this method have, according to Prof. Johnson, a specific gravity of 1.2 to 1.3.

Leavitt's process.—Mr. T. H. Leavitt, of Boston, Mass., in 1865, invented the following machinery and method of manufacturing peat: "The machinery consists of a strong tank or cistern, three feet in diameter, and six feet high, supported upon a stout framework about four feet above the floor of a suitable building, which should be near the bog, and is best constructed on a side-hill so that easy access can be had to the lower story on one side from the base of the hill, and to the second story on the other side. The top of this tank is open, and even with the floor of the second story. Within the tank, and firmly fixed to its sides, are numerous projections of a variety of forms, adapted to the treatment of the material in its several stages as it progresses through the mill, which is divided into three apartments; through the center of the tank revolves an upright shaft to which are affixed knives and arms varying in form and structure to correspond with the stationary projections in each apartment; below the tank is a receiver, or hopper; and under this is a moulding or forming machine, two feet in width and twelve feet long, of like simple construction, which receives the condensed material from the hopper and delivers it in blocks of any desired form and size. The whole

is adapted to be driven by a small steam engine and requires about six and ten horse-power respectively for the two sizes of machines as at present constructed, of the capacity of fifty and one hundred tons each of crude peat, per day of ten hours.

"The crude material is brought from the bog in ordinary horse-carts, or on small cars running over a cheaply constructed tram-way, to the mouth of the mill, in the floor of the second story of the building, where it is dumped or shoveled into the mill in any convenient quantity; but the arrangement is such that only a given amount is admitted, and under treatment at one time, so that all parts have a uniform and regular supply. The treatment is such that the original organization of the peat is entirely destroyed; in the second stage, the air, of which a large amount is contained in its cells, is ejected; advantage is taken of some of the natural properties of the material, and the mass is condensed in the moist state in the lower part of the mill, from whence it is delivered into the hopper of the moulding machine, and is discharged in a continuous line of moulds (which are fed into the rear part of the machine by a boy), at the rate of fifty to one hundred tons per day of ten hours. The work of removing the blocks to the spreading ground is easily accomplished; and they are exposed in the open air for drying, in much the same manner as bricks are exposed in a brick-yard.

"The amount of water contained in well drained peat is ordinarily from 65 to 75 per cent., varying according to the character of the material and the drainage of the meadow; so that the weight of dry, hard fuel from the product of a day's operations, is from 12 to 17 tons, or 25 to 35 tons, from the two sizes of machines respectively.

"The water remaining in the blocks as they come from the mill can be got rid of only by evaporation, which goes on very rapidly after this method of treatment; and the fuel is, at the expiration of about six to ten days, sometimes in four or five, in condition to be housed or transported to market."

The Rae process.—This invention, patented May 22, 1866, was made by Dr. Julio H. Rae, of Syracuse, N. Y. It is thus described in a circular issued by the owners: "The peat is delivered into a top of a cylinder placed in a vertical position, in which is a revolving shaft, to which are permanently fastened, near its top, two or more arms, which are set at an angle with the axis of the shaft, their

office being to draw down the peat from the top of the cylinder and feed it along into that part of the cylinder where it will be subjected to the action of the revolving knives or cutters, which are found on the under side of the blades projecting from the shaft, and placed at an angle with the axis of the shaft. The number of blades can be varied, and also the number of cutters on the blades. In a cylinder of about four feet in length about seven such blades can be used advantageously. They are arranged around the shaft in spiral order, and are so inclined that the front edge of each blade is higher than the rear edge, whereby they are made to give a downward impulse to the peat as they revolve. Below the lowest blade is a propeller, consisting of a series of blades, each bent so as to form a section of a screw, but the blades are fastened to the shaft in the same plane. The office of the propeller is to seize the peat and press it downward through an opening in the bottom of the cylinder into a chamber, wherein are placed conveyors that convey and force the peat into condensing and discharging tubes that project through the sides of the chamber. The condensing tubes and the conveyors are placed in a horizontal position, the ends of the conveyors reaching a little way within the tubes, but they can be arranged in any other desired position. The inner ends of the tubes are cylindrical and the tubes gradually decrease in diameter for about one-half their length, so as to resemble the frustum of a cone. From or near the point of their greatest contraction, the tubes assume a shape nearly semi-cylindrical, retaining that shape to their outer ends, and gradually increasing again in diameter. The rounded upper side of the tubes at their discharge end, gives a corresponding rounded form to the peat that is forced through them, but any other form may be adopted. The peat is received from the ends of the discharging tubes on the ground or upon a traveling belt or platform, and may be cut up immediately into proper lengths, convenient to be handled in drying.

"There are four sizes of these machines, viz.:

"No. 1, requiring about one horse-power, designed for farmers, is capable of turning out per day what, when properly dried, will make from four to six tons of merchantable fuel.

"No. 2 is double the capacity of No. 1, requiring about two horse power.

"No. 3 is a combination of Nos. 1 and 2, nearly double their capacity, requiring from four to six horse power.

"No. 4 is more than double the capacity of No. 3, requiring from eight to twelve horse power, and capable of turning out per day enough peat to make, when cured, forty tons of merchantable fuel."

These machines were run, a few years ago, by the *Minnesota peat company*, of St. Paul, and the *Minnesota packet company*. In simplicity of construction, and in power and capacity, these mills seem to excel. They also have a very great advantage over Leavitt's and all others employing moulds for giving shape to the condensed peat. The use of the moulds is cumbersome and expensive.

The Aubin process.—This method was inaugurated at Meriden, Conn., in 1870. It covers different patents, designed for economizing labor, obtained in 1868 and 1869. The following description is from the circular issued by the agent in New York, in 1870: "If the manufacture of the fuel is to be carried on upon a limited scale, of say five tons, or thirty to fifty tons per day, hand labor, with the ordinary long-handled shovel, is probably the simplest and cheapest way to get the peat *up* from the deposit: it is then thrown into wheelbarrows, and if the distance is not too great, can be dumped directly into the mouth of the elevator. When peat to be dug is at a sufficient distance from the machine to justify or necessitate the use of cars, then a set of double portable rails can be employed. When the swamp cannot possibly be drained, the use of scows or wire tramways may be resorted to. For large operations, to supply railroads or manufacturing districts, a steam digger, on a scow, or on tracks, will be, of course, cheaper than hand labor.

"The peat, once dug and conveyed from the pit, falls into a large hopper, from which a screw elevator, especially devised for peat, propels it up to the slicing and cleaning apparatus, placed above the grinding and puddling cylinder. When the bog cannot be drained, the peat taken from it contains, of course, too large a proportion of water for thorough and economical working; in such case the elevator is furnished with a *wringer*, which can be operated or not, at will, and arranged to separate the surplus water as the material passes through it. The peat, in a fit condition to work up well, being elevated in a continuous and evenly-fed supply, falls into the *slicer and cleaner*. This portion of the apparatus is composed of a series of rapidly revolving cutters, which owing to their peculiar form and position, slice the peat and separate from it all hard or foreign substances.

From the slicer and cleaner the peat, *still better fitted* for grinding, falls into the *grinding and pulverizing* machine. This is a cylinder three feet in diameter by six feet long, and made of boiler-plate iron. The cylinder itself is stationary, but within is a large revolving iron drum, eighteen inches in diameter. To this are bolted in two spiral rows, forty-four cast iron knives, all nine inches long, but of three slightly varying shapes, and three sizes, increasing toward the mouth of the cylinder. These knives are named, according to size, *cutters*, *grinders* and *puddlers*, and remind one very much of the three kinds of teeth, incisors, canines and molars. They are between one and three inches in thickness and have each several square corners, but no sharp edges. Attached to the inside of the cylinder, under the drum, is a corresponding fixed series of twenty-two nearly crescent-shaped iron knives. Between these and the revolving knives the peat is carried along, cut, ground and perfectly "pulped," and falls, finally, into a sluggish stream, through a spout a foot or more square, into a large wooden moulding hopper. Along one side of the cylinder is the "stone pocket," a long, spacious iron trough, placed horizontally. It has an exterior cover for removing its contents, and communicates with the interior of the cylinder, to which it is attached in such a position that the revolving knives necessarily throw any stone or other hard substance into the pocket, instead of crushing it against the fixed knives. This contrivance is simple and effective. Under the moulding hopper is a series of rollers set in a long, stout frame, about four feet high and three feet wide, called the *conveyor*. One man puts a shallow wooden box or mould into a trough of water. Another submerges and removes it and lays it on a little branch of the conveyor. Here a wooden *pusher* strikes it a blow and sends it on the main conveyor; another drives it into the narrow space under the moulding hopper, where the weight of the peat and the hopper's peculiar shape fill it, before another blow from the same pusher forces a second mould under the hopper and expels the first. Other moulds rapidly follow, moving the first slowly along till a third pusher thrusts it upon a little side-shelf, from which two men easily set it down with eleven of its fellows, in three piles of four each, upon a wooden four-wheeled car.

"The drying field is a large, smooth meadow, crossed by two main tracks, running 1,500 feet in a straight line from the machine, and intersected at right angles by cross-tracks, 150 feet apart, and running 300 feet each way from the

main tracks, with turn-tables at the junctions. These tracks are three feet wide, and laid with iron rails near the machine, and wooden rails where the wear is less. There is a short switch-track, built so that three cars, instead of two, can be run up to the conveyor at once, though only one can be loaded at a time.

"The pulverized peat is so tenaciously adhesive that the moulds used are of a novel construction, to meet this difficulty. They are four and a half feet long by two feet wide, and five inches deep. The corners are secured with iron clamps, and an extra strip is nailed at each end to serve as a handle. The bottom is removable, and across it are fastened, at equal distances, ten pine strips, about two and a half inches high and an inch wide at the base, but beveled off on each side to one-third that thickness at the top. These moulds cost about $2.50 each, and about 500 of them are in use.

"Each car is propelled by two men. Four men unload it. Two seize a mould, one at each end, walk briskly away with it to the place where it is to be dumped, tip it wrong side up, jerk off the side frame, and drop it on the grass, pick the bottom off the sticky mass of "pulp," toss it into the frame, catch up the empty mould again, and trot back to the car. This process is repeated with the other moulds. When first emptied, the wet, black peat is just dense enough to keep its shape; but in the warm season it hardens so fast that within forty-eight hours it will resist the severest storm, and then resume the drying process when the weather clears, at the point where the rain interrupted it. Strange as it may seem, this peat fuel absorbs much less water than wood does, and hence can be dried on the bare earth, under the open sky. It does not even adhere to the grass, which, however, is soon worn away.

"As it dries the peat shrinks to about half its first thickness, changes color from black to brown, and cracks along the grooves, so that when it is half dry, boys can easily 'hack' it—*i. e.*, break each mould into about twenty pieces, and pile it in two or three small, loose heaps. In two weeks or a month, according to the weather, the peat is dry enough to be gathered by men or boys, in baskets, barrows or carts, and stored in covered wooden sheds, with wide cracks between the sideboards to admit air, and the ends left open.

"The capacity of the three foot cylinder per day, at thirty revolutions regularly fed, is seventy-five tons of dry fuel.

Whatever be the number of revolutions, the moulding machine adapts itself to the demand.

"The cost of machinery, including *engine, boilers*, and entire equipment, is dependent on the amount of fuel it is required to be produced by the operator; being for small works, intended for horse power—say five tons per day—about $200; for a product of 250 tons per day, about $20,000—an engine of eighty horse power being required to drive the latter."

Haight's process.—This is the invention of Mr. W. Z. Haight, of Delavan, Faribault county, Minnesota. It has been successfully operated at Fairmont, in Martin county, and at Wells, in Faribault county. At the latter place it was taken for locomotives by the Southern Minnesota rail road. The works at this place have been thus described by the Wells *Atlas*:

"A bold bank is selected, in order to secure a good drying yard close to the bog, on which the engine and machinery is located, where a frame is erected 12x16 feet and eight feet high, from the top of which a wooden car track, supported by a light trestle-work, descends to the surface of the bog, a distance of 150 feet, with a fall of 25 feet. From that point the track is made in sections of 14 feet each, which are portable, thrown down on the surface of the bog, and with the use of a few curved sections, the track can be shifted in any direction so as to excavate the entire bog that is in reach. This track can be extended many hundred feet out across the surface of the bog, if desired, giving access to several acres. On this track one car plies, which is loaded by three men who stand by the edge of the excavation, (water being lowered about six inches from the surface to insure dry feet). The sod is cut up into chunks, with sharp, diamond pointed, spade like tools, from two to four feet deep, according to depth of the peat, and left submerged in the water until the car is at the proper place, when the chunks are pitched from the water into the car, with common four-tined forks, and when the regular amount, about two tons, is loaded into the car, it is hauled by the power of the engine up the incline, over the large platform under which the mill is situated, and by a simple contrivance the car is made to dump its load, also to unship the windlass from the power that hauled it up, being no trouble to the feeder, who at will starts the car back, which, in going down the inclined plane gains momentum that carries it out hundreds of feet along the level track. Meanwhile the men in the bog do the necessary work, cut-

ting chunks for another load, so there is no time lost in the absence of the car. The feeder, who stands on the platform, then feeds the turfy mass into the mill, which is an ingeniously constructed machine, though simple, very durable, so arranged with knives cutting through grates, pickers, conveyors, etc., that it will treat the most fibrous mass or sod peat that can be produced and reduce it to a pulp or jelly at once, and that too without clogging or winding in the machine. Owing to its perfectness it renders it unnecessary to strip off the top sod from the bog, all that is necessary being to mow off the grass or other vegetation, if there is any growing thereon, thereby saving considerable expense in labor, also a good part of the fuel, when ground up with the lower or more decomposed peat. By the conveyers, the peat, as fast as pulped, is forced through a pipe into a vat with dump bottom, which holds one cart load. Here the cartman receives it by driving his cart under and dumping a load into it from the vat, adjusts the vat botton, drives to the spreading ground, dumps his load from the cart and returns, during which time another load has accumulated in the vat. The pulp is dumped on a smooth plat of ground, where a man with a common shovel spreads it into beds four inches thick, nine feet wide, and as long as necessary, setting up boards at the sides to keep it from spreading, who is followed by another man with a tool similar to a rolling colter for a plow, fixed on a long handle, who cuts the bed of soft peat into blocks 8x13 inches, which commence to solidify at once by the ejection of the water, and in one or two days, by the use of a light tool made expressly for the purpose, these blocks are tipped up on edge or corners promiscuously, so the sun and wind can have a better chance at them. In two days more they are piled in open ricks, in which posture they remain on an average, two weeks, when they are housed to finish drying.

"The cost, the past season, of running this establishment, at a capacity of 60 tons of wet or 15 tons of dry peat per day, (equal at least, when properly prepared and well seasoned, to 15 cords of good wood,) is as follows:

Superintendent	$2 50
Engineer per day	2 75
Three men in bog to load car	6 00
Man to spread pulped peat into beds	1 50
Boy to turn up blocks	1 00
Two boys to rick up blocks	2 00
Man to feed peat into mill	1 50
Boy to drive cart	1 00

Man to cut peat into blocks	1 50
Cart horse	1 00
One ton peat at cost price for engine	1 72
For oil, and wear and tear on engine	1 00
Add 22 cts. per ton for housing 15 tons, one day's product	3 30
Total	$26 77

"All the peat is being sold at $4.00 a ton, except that to the Railroad Co., at which price the yield per day would be $60.00. Subtract from that the amount of expenses, $26.77, leaves $33.23—a handsome profit. The price of peat per ton should be estimated equal to that of good wood per cord, sawed and split for stove fuel, and unsawed for steam powers.

"The cost of an establishment, excepting engine and drying sheds, capable of manufacturing 100 tons of wet peat, or 25 tons when dry, per day,—mill $400. Frame, trestle-work, car track, car, dump cart, etc., about $300.

"This is the cheapest mode of utilizing the peat, both as to the matter of machinery and labor, that we have any account of, and as it has been practically proven a success at this place, we see no reason, if the same plan be followed, why it should not be equally successful elsewhere."

It must be admitted, however, that although great progress has been made in this country in the construction of machinery for the manufacture of peat, a great deal of labor and capital have been consumed to no purpose. Many of the companies that, with hundreds of thousands of capital each, sprang into existence a few years ago when a feverish excitement spread over the country in reference to peat, have entirely disappeared, and nothing remains to witness their folly but the idle and rusty machinery they "invented" or purchased, and the almost forgotten titles to thousands of bogs, which they eagerly bought. This phase of the peat enterprise is not, however, the just criterion by which to judge of it. It is only an index of a deep seated want. The unmatured developments of the first peat agitators in this country were enough to start into a flame the desire of the people for relief from the high prices of wood and coal. The result was a wide-spread speculation. From this there has been a corresponding reaction. This however does not in the least affect the real value of peat as a fuel, nor detract from the credit of the inventions that have been made. Sober-minded men, consumers of large quantities of fuel, have in some instances, and in various parts of the country, steadily and persistently followed up the matter. Here and

there a railroad, an iron-furnace, a manufacturing establishment or a family has continued to produce and use peat fuel until it has won much of its lost favor, and is now in actual demand by consumers of the heaviest class, who are ready to purchase largely and at highly renumerative prices. This demand however is one that will not be met by anything less than a constant and steady supply, equal to its requirements. It calls for the best machinery, equipped with the best facilities and aids, and backed by large capital. The following extract is from a letter to the writer from T. H. Leavitt, of Boston, dated Dec. 3, 1873:

"The most active and really practical operations in peat and its utilization of which I have present knowledge are in the lake Superior iron regions of Michigan.

"In October last I made a trip there and at Ishpeming, near Marquette, witnessed the successful use of peat fuel for the smelting of the ores of that region. Operations more or less experimental have been quietly prosecuted there during the last four years. A furnace of moderate capacity, especially adapted for smelting with peat, has recently been constructed and was put in operation about ten days before I was there, and was then in most perfect operation, and was considered a decided success as regards economy, ease of management, quality and quantity of metal produced, &c.

"The fuel was very poorly made, (lacking the density which might easily be given it, weighing 35 lbs. per bushel, whereas it might probably be made to weigh 40, 45 to 50 lbs. at no greater cost,) and in many things they lacked experience, but all appeared enthusiastic of their success. They commenced with charcoal and ten per cent. peat, gradually increasing until at the time I was there they were using upwards of 70 per cent. of peat, and were only waiting permission from the agent to use *all* peat, which the furnace men assured me they were convinced would be not only successfully done, but be actually better than to use any mixture of charcoal. The metal produced was regarded as fully equal in quality and perhaps superior to the very best grade ever produced in that region.

"Considering the immense quantities of peat in that region and the success attained with a fuel so poorly manufactured, I can but feel that for that region and its iron interests the peat fuel enterprise has yet a prominent and very important place to fill.

"The cost of producing the fuel there is stated to be $3 per ton."

(h) *The value of peat for fuel.*

It is not intended here to attempt the details of experiments and comparisons with the view of demonstrating the usefulness of peat as a fuel for domestic and metallurgical purposes. That has already been abundantly attested by the approval of railroad engineers, who have used it, and are still using it, both in this country and in Europe, and of owners of furnaces and manufacturing establishments, as well as by the testimony of chemists and government commissioners that have reported on its working, in France, in Germany and in America. The following tabulated comparisons are given for the purpose of placing within reach of those within the state interested in this subject, reliable means of estimating the cost of peat, and its heating capacity, compared with other kinds of fuel. These are the results of careful and long continued experimentation:

(1) *Weight for weight.*

The following comparisons are given by Gysser, on certain woods and charcoals in Germany, the basis being equal weights of each.*

Beech wood, split, air-dried	1.00
Peat, condensed by Weber and Gysser's method, air-dried with 25 per cent. of moisture	1.00
Peat, condensed by Weber and Gysser's method, hot-dried, with ten per cent. moisture	1.48
Peat charcoal, from condensed peat	1.73
The same peat, simply cut and air-dried	.80
Beech charcoal	1.90
Summer-oak wood	1.18
Birch wood	.95
White pine wood	.72
Alder	.65
Linden	.65
Red pine	.61
Poplar	.50

"The general results of the investigations hitherto made on all the common kinds of fuel, are given in the subjoined statement. The comparisons are made in units of heat, and refer to equal weights of the materials experimented with." [*Peat and its uses*, p. 102.]

*See Prof. Johnson's "Peat and its uses," p. 97.

Air-dry wood		2,800	
Air-dry peat	2,500		3,000
Perfectly dry wood		3,600	
Perfectly dry peat	3,000		4,000
Air-dry lignite, or brown coal	3,300		4,200
Perfectly dry lignite, or brown coal	4,000		5,000
Bituminous coal	3,800		7,000
Anthracite coal		7,500	
Wood charcoal	6,300		7,500
Coke	6,500		7,600

(2) *Bulk for bulk.*

One of the greatest obstacles to the general use of peat for fuel consists in its bulkiness. Uncondensed peat, air-dried, will occupy two and a half times the amount of storage room that anthracite coal will, the weights being equal. As it is also of lower heating capacity, requiring two and a quarter tons of peat to equal one of anthracite, the bulk required for the peat would be equal to five and five-eighths times that of coal. By condensation peat is greatly improved in heating capacity and in convenience in handling. Johnson gives the following as the composition and density of the best condensed peat, compared with that of hard wood and anthracite.

In 100 parts.	Carbon.	Hydrogen.	Oxygen and nitrogen.	Ash.	Water.	Specific gravity.
Wood	39.6	4.8	34.8	0.8	20.0	0.75
Condensed peat	47.2	4.9	22.9	5.0	20.0	1.20
Anthracite	91.3	2.9	2.8	3.0	....	1.40

The heating power of peat, of the different qualities, taken from different depths, compared with pine wood, are thus given by Prof. Johnson, after Karmarsch, equal bulks being taken instead of equal weights:

100 cu. ft. of turfy peat, on the average,	=33	cu. ft. of pine wood in sticks.
" fibrous " "	=90	" " "
" earthy " "	=145	" " "
" pitchy " "	=184	" " "

The following also shows the relative heating effect and weights of an English cord of oak wood (taken at 100 as the standard) and of several European air-dried peats, bulk for bulk, quoted from Brix by Prof. Johnson:

	Weight per cord.	Heating effect.
Oak wood	4,150 lbs.	100.
Peat from Linum, 1st quality, dense and pitchy	3,400 "	70.
" " 2nd quality, fibrous	2,900 "	55.
" " 3rd quality, turfy	2,270 "	53.
Peat from Buechsenfeld, 1st quality, hard and pitchy	3,400 "	74.
Peat from Buechsenfeld, 2d quality	2,730 "	64.

(i) *What has been done in peat.*

A few years ago the question of manufacturing peat was put to a practical test by the *Minnesota peat company*, located at St. Paul. The Rae machinery was used. The work was continued long enough to show that it was not profitable at the current prices of wood, and was suspended. A similar attempt was made at Red Wing, about the same time, and with the same result. The process used there is not known. In southern Minnesota Mr. W. Z. Haight has prosecuted the manufacture more successfully, and is now engaged in erecting the necessary buildings and apparatus for working peat by his process the coming season, at Lura station, in Faribault county. He produced, at a cost of two dollars per ton, a good fuel at Wells, in the summer of 1871, with his machinery, which was well suited for use in locomotives. The stoppage of his work there was not due to a failure to produce a good fuel, nor to its being too costly, but, he says, to a lack of demand sufficiently large to warrant extensive operations. His method is described in a preceding section. Except the preparation of small amounts in St. Paul, by Dr. C. D. Williams, for experimentation, the foregoing are believed to be the only attempts that have ever been made in the state of Minnesota, to produce from the peat deposits of the state a fuel for general consumption by any process of manufacture.

(j) *Raw or manufactured peat.*

Some experiments have been made by Dr. C. D. Williams on a fuel made by a saturation of turf-peat with the residuum, or "shale oil," that is a product of the petroleum refineries of Pennsylvania. These trials demonstrate that a good fuel may thus be formed. The combustible material in the turf itself is not so much as in true peat. The analyses of Prof. Peckham show the greater per cent. of ash in excess of that of peat. This shale oil has a carbonaceous composition, not yet certainly ascertained, consisting very largely of carbon and hydrogen, both of which are combustible. The adding of the shale oil to the turf not only increases by so much the combustible material in a given bulk, but improves the quality of the fuel. By this means some of the poor peats may be made serviceable, at a cheaper rate, perhaps, than by the process of manufacture. The following facts in reference to the cost of this shale oil

delivered at Worthington, in Nobles county, are on the authority of Dr. Williams. The residuum can be had for removing it from the vats:

Cost of barrel containing 43 to 45 gallons	$1 50
Cost of filling and drayage to cars, per barrel	50
Charges Pittsburgh, Fort Wayne & Chicago R. R. to Chicago	1 00
Charges West Wisconsin R. R. to St. Paul	1 00
Charges St. Paul & Sioux City R. R. to Worthington	1 00
Add for profits to dealer	1 00
Cost at Worthington per barrel	$6 00

(k) *Practical conclusions on peat.*

1. There is not so much real peat in the state of Minnesota as has been supposed. There is a great abundance of turf, made up of grass roots, containing a large per cent. of ash, not properly called peat, that will furnish, in any exigency, a fuel that will keep a family from suffering. This, however, is not thought the object of the survey to investigate, nor to locate, as it exists, as is often stated in the public press, on almost every square mile.

2. While a good fuel, almost equal to the Iowa coal, can be produced by the manufacture of peat by a process of condensation and evaporation, it is far from certain that it will not cost as much, or more than wood or coal at the present prices.

3. If in any part of the northwest peat can be made useful as a fuel by manufacture, it is the woodless and coalless region of southern and western Minnesota.

4. Cautious experimentation should be carried on by those interested in the subject, with the view to test the comparative cost of peat, wood and coal, at the prices current in different localities.

5. The farmers, and others who need fuel, but do not have means to produce a condensed peat, can take out in mid-summer a winter's supply, from the turf peat found on many farms in the prairie region, but they will generally not find it possible to utilize the real peat deposits without some method of manufacture. They will be too apt to crumble, and thus make a slow, smoldering fire.

6. There is no known instance of the existence of peat, in Minnesota along river valleys, on the bottom lands, where the surface is subject, at the present time, to inundation by spring freshets.

7. There are old river channels, or valleys of excavation,


MAP OF
MINNESOTA.
Showing the Location of the Counties.
Total area 84,286 square miles.
BRITISH POSSESSIONS
PEMBINA
BELTRAMI
ITASCA
POLK
ST LOUIS
CASS
BECKER
CLAY
WADENA
CARLTON
AITKEN
CROW WING
PINE
OTTER TAIL
WILKIN
TODD
MORRISON
KANABEC
MILLE LACS
GRANT
DOUGLAS
TRAVERSE
STEVENS
POPE
STEARNS
BENTON
ISANTI
SHERBURNE
ANOKA
BIG STONE
SWIFT
WRIGHT
RAMSEY
WASHINGTON
LAC QUI PARLE
CHIPPEWA
KANDIYOHI
MEEKER
RENVILLE
CARVER
YELLOW MED
SCOTT
DAKOTA
LINCOLN
LYON
REDWOOD
BROWN
NICOLLET
LESUEUR
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
MOWER
HOUST
DAKOTA TERRITORY
IOWA
WISCONSIN
LAKE SUPE
Duluth
Moorhead
Fargo
Brainerd
Stillwater
Hudson
Prescott
LAKE PEPIN
NORTH WISCONSIN R.R.

both in the drift and between rocky bluffs, that no longer exist as rivers, which contain considerable deposits of peat.

8. There are depressions in the rolling drift surface, in some localities, which, fed by invisible springs, maintain a nearly uniform stage of water throughout the year, and may hold peat of the best quality.

9. But a small portion of the state has been examined. In that a much smaller amount of peat was found than had been anticipated. Other portions, and especially the central southern counties, are believed to promise more peat than the counties examined. According to Dr. C. A. White, state geologist of Iowa, a peat bearing belt enters Minnesota from the south, bounded, in general, by the Des Moines on the west, and the Cedar on the east.

10. Large quantities of peat are believed to exist in the northern part of the state, many of the cranberry marshes being peat bogs of great purity.

11. The value of peat as a common fuel having been demonstrated, and its existence in sufficient quantities within the state having been ascertained, it becomes a legitimate expedient for the State to stimulate the invention of successful methods of utilizing it by offering rewards.

III.

THE GEOLOGY OF THE MINNESOTA VALLEY.

(a) PRELIMINARY CONSIDERATIONS.

In the fall and winter of 1766 Jonathan Carver explored the valley of the Minnesota, but aside from the mention of the rapids near Shakopee, he has given no information of the geology of the valley, although he claims to have ascended it a distance of two hundred miles above Mendota.

The expedition of Maj. S. H. Long was undertaken in 1823, by order of John C. Calhoun, secretary of war. The

able historiographer to the expedition was Wm. H. Keating, who also served as geologist. He was appointed from the University of Pennsylvania, where he occupied the chair of mineralogy and chemistry. This party ascended in canoes a distance of 130 miles, when they abandoned them for the land, following the valley to Big Stone lake, thence descending the Red River valley to lake Winnipeg. The observations of Prof. Keating on the geology of the Minnesota valley, are the earliest, with the exception of the doubtful accounts of Le Sueur, of the copper mines on the Blue Earth, that we have any knowledge of, although an old map accompanying the *Recueill de voyages*, published in Amsterdam in 1720, shows a "coal mine" located some distance up the Minnesota. They were made with that haste which a traveling geologist always finds unavoidable when he is acting simply as an accompaniment to an expedition, instead of its guide and commander. No time could be spared to indulge the geologist in making such detailed observations as would enable him to state emphatically the bearings of isolated facts, which he picked up, on each other, or to generalize with any certainty. He could simply act as a gatherer of facts. His success lay in the exactness and fullness of his observations. Prof. Keating's geological observations may be summarized in the following descending section :

1. The bluff at Fort Snelling, made up of (a) slaty or splintery limestone, 8 feet: (b) blue limestone, useful for building, 15-20 feet; (c) sandstone, 60 feet: (d) earthy argillaceous limestone 10 feet: (d) crystalline and conglomeritic limestone, 4 feet; (e) a limestone of finer grain and more earthy texture than the last in which the river is excavated at the fort. Keating is the only geologist that has ever reported limestone *in situ* below the sandstone (c) at Fort Snelling. Six miles below the small Indian village Weakaote, he notes the occurrence of the Little Rapids, caused by a sandstone in horizontal stratification "in every respect similar to that found at Fort St. Anthony." The same sandstone is again mentioned as occurring near Kasota, having horizontal ledges of rock overlying it, supposed to be the same as seen at Fort Snelling. The banks of the Redwood river, near its mouth, are said to be made up of "a fine white sandstone."
2. "Primitive rock" was first seen *in situ*, several miles above Patterson's rapids, which are a few miles above the mouth of the Redwood river, and was examined very carefully and described in detail. He remarks in general : "It seemed as if four simple minerals, quartz, feldspar, mica and amphibole, had united here to produce almost all the varieties of combination which can arise from the association of two or more of these minerals." Owing to its confused and various composition, he compares it to that seen at a subsequent period of the expedition, between lake Winnipeg and the lake of the Woods. He regards all that section of country between Patterson's rapids and the upper Mississippi, and thence

to Fort Alexander, at the mouth of Winnipeg river, as underlain by granite and sienitic granite. These rocks are again mentioned at a point five leagues above Lac qui Parle, at the mouth of Spirit Mountain creek.

In the fall of 1835, G. W. Featherstonhaugh's ascent of of the Minnesota occured. His geological observations were very meagre. He took the pains to ascend the Blue Earth a short distance in search of the copper mine of Le Sueur. Keating did not visit it, passing it with the simple remark that he believed the substance obtained by Le Sueur to be a phosphate of iron, judging simply by its color. Mr. Featherstonhaugh says: "The Mahkatoh appears to form about half the volume of the St. Peter's, and is a very rapid stream. The Sissitons we had met, told us it forked eleven times, and that the branches abounded in rapids and shallow places. About twelve, we came to a fork or branch coming in on our right, about forty five yards broad, and we turned into it, having a well wooded bluff on the right bank about ninety feet high. The stream had very little current, owing to the main branch, which we had just left, rushing down with great velocity and making back-water here. We had not proceeded three-quarters of a mile when we reached the place which the Sissitons had described to us as being that to which the Indians resorted for their pigment. This was a bluff about 150 feet high on the left bank, and from the slope being very much trodden and worn away, I saw at once that it was a locality which for some purpose or other had been frequented from a very remote period. We accordingly stopped there, and I told the men to make a fire and warm themselves, whilst I examined the place.

"As soon as I had reached that part of the bluff whence the pigment had been taken, Le Sueur's story lost all credit with me, for I instantly saw that it was nothing but a continuation of the seam which divided the limestone from the sandstone, and which I have before spoken of at the Myah Skah,* as containing a silicate of iron of bluish-green color. The concurrent account of all the Indians we had spoken with, that this was the place the aborigines had always resorted to to procure their pigment, and the total silence of everybody since Le Sueur's visit, respecting any deposit of copper ore in this or any other part of the country, convinced me that the story of his copper mines was a fabulous

*Myah Skah is "white rock bluff," supposed to be the bluff at Ottawa, in Le Sueur county.

one, most probably intended to raise himself in importance with the French government of that day. Charlevoix having stated that the mine was only a league and three-quarters from the mouth of the Terre Bleu, made it certain that I was now at that locality, and the seam of colored earth gave the key to the rest. Le Sueur's account of the mine being at the foot of a mountain ten leagues long, was as idle as the assertion that he had obtained 30,000 pounds of copper ore in twenty-two days, for there is nothing like a mountain in the neighborhood. The bluff, to be sure, rises to the height of about 150 feet from the river; but when you have ascended it you find yourself at the top of a level prairie, so that what might to an inexperienced traveler appear to be a mountainous height, is nothing but the summit of the gorge which the river has cut out." [*Canoe Voyage up the Minnay Sotor*, *Vol.* 1 *p.* 303.]

With the exception of an occasional mention of granite in place, and a very brief notice of the red quartzite near the mouth of the Waraju river, the foregoing is the only geological note of importance recorded by Mr. Featherstonhaugh on the valley of the Minnesota.

In the survey of Wisconsin, Iowa and Minnesota by Dr. D. D. Owen, the examination of this river was committed to Dr. B. F. Shumard. Dr. Shumard and his party ascended the valley in canoes as far as the Redwood river, where he was attacked with pleurisy, and was compelled to abandon the further prosecution of the survey. This was in June, 1848. His report exhibits the first attempt ever made to parallelize the rocks of the valley with those of the rest of the state, and determine their geological age, and their equivalents in other states, by reference to a standard of comparison. That standard was a nomenclature adopted by the chief of the survey, based on the New York survey, as follows, with its equivalents:

No. 1. *Formation* 3, *C*. Corralline and Pentamerus beds of the Upper Magnesian limestone. (The Niagara group of New York.)

No. 2. *Formation* 3, *B*. Lead-bearing beds of the Upper Magnesian limestone. (The Utica Slate and Hudson River group.)

No. 3. *Formation* 3, *A*. Shell-bed. (The Trenton and Black River limestone of New York.)

No. 4. *Formation* 2, *C*. Upper, white saccharoid sandstone, or St. Peter sandstone.

No. 5. *Formation* 2, *A. and B*. Low. Magnesian limestone. (The Calciferous sandrock of New York.)

No 6. *Formation* 1. Lower, light-colored quartzose sandstone. (The Potsdam sandstone of New York.)

No. 7. *Red, argillaceous and ferruginous sandstones*. (Supposed to be a downward extension of the Potsdam sandstone.)

Of these Dr. Shumard recognized Nos. 3 and 4 at the mouth of the river, in the Fort Snelling bluff. At Shakopee, and thence to the Little Rapids, he notes No. 5. The sandstone at the last place he regards as belonging to a formation several hundred feet below the white sandstone of No. 4, probably to No. 6. At "white rock bluff," situated on the right bank of the river, about six miles below Traverse des Sioux, he regards the exposed section to consist of No. 6, capped with No. 5, about fifty feet of the former and fifteen of the latter. The same formations are exposed, at intervals, to the mouth of the Blue Earth river, where the section is said to be similar to that of *white rock bluff*. Ascending the Blue Earth river six or eight miles and observing the same geological horizon as far as he went, he notes, subsequently, two or three exposures of No. 6 before reaching the mouth of the Waraju river, one being two miles below the mouth of that stream. The red quartzite at the mouth of the Waraju he regards as the lower beds of No. 6, more or less altered by metamorphism where they abut upon the igneous rocks. He also notes conglomerate and granite outcrops about a mile in a straight line above the mouth of the Waraju. He mentions granite at La Petite Roche, twenty-five miles above the mouth of the Waraju, and at frequent other points before reaching the Redwood. He describes an interesting exposure two or three miles below the mouth of this river.

There will be further occasion to refer to Dr. Shumard's report, since, although in the main corroborated by the observations of the past season, additional facts have been gathered which necessitate some change in his parallelisms.

(b) THE TRENTON LIMESTONE AND SHALES.

After leaving the immediate vicinity of the mouth of the river, this formation is not seen again throughout its course, consequently no new facts can be given respecting its characters or extent, except those noted in Dakota county.

The quarry of Daniel F. Aiken is a mile and a half northwest of Farmington, on sec. 24 T. 114, R. 20. The beds show a considerable disturbance, and a portion of the usual building-stone, belonging to No. 4 of the section below, appears to be wanting from that cause. Yet Mr. Aiken is positive that no greater thickness of No. 4 exists there than that seen.

Section at Daniel F. Aiken's quarry, near Farmington. Dakota Co.

No. 1.	Shattered, loose beds of limestone........	5 feet.
No. 2.	Shale..............	6 "
No. 3.	Stone, which crumbles to shale........................	2 "
No. 4.	The Minneapolis quarry stone..........................	4 "
	Total..	17 feet.

In traveling south on the Sioux City railroad, from Fort Snelling, the form of the brow of the bluffs of the Minnesota valley, appear to lose the Trenton on the east side of the river several miles sooner than on the west side. On the east side the limestone extends about three and a half or four miles above the fort. On the west side it seems to continue in the bluffs, though hid from sight, for a distance of six or eight miles.

(c) THE ST. PETER SANDSTONE.

This, like the Trenton overlying, also disappears from view soon after leaving Fort Snelling. Owing to its destructible nature, it is very rarely seen except when protected by the Trenton. Yet at one other point has it been discovered in the Minnesota valley. A very interesting observation was made at the Asylum quarry, at St. Peter, in Nicollet county. The stone there wrought is the first below the St. Peter sandstone, the Shakopee limestone, the uppermost member of the Lower Magnesian. In the top of the quarry, where the workmen had stripped off the loose drift materials, about two feet of a white, friable sandstone were seen, with a thin strip of green shale about midway in it. This lay, in place, over the limestone, and afforded the only recorded observation ever made on the very base of the St. Peter sandstone. It seems to maintain its strictly arenaceous character, or very nearly so, to its very contact with the limestone. This observation confirmed the belief, derived from the examination of the valley to that point, that the St. Peter and the Kasota quarries were in the same horizon as the Shakopee quarries, and that they all occur within the first thirty feet below the St. Peter sandstone.

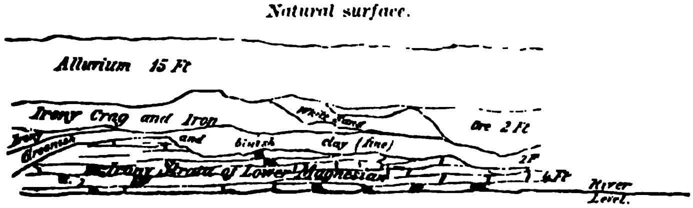
A friable, white sandstone, believed to be the St. Peter, was again observed, about two miles above the mouth of the Maple river, in the banks of which it affords a number of exposures. Those examined were in the northeastern part

of Rapidan township, in Blue Earth county, (T. 107, R. 27, secs. 11, 12 and 13). It is here underlain by about two feet of a greenish-blue clay, and is associated with concretionary and irregular sheets of brown hematite. In the banks of the Maple, where the Shakopee limestone is exposed and somewhat quarried, there are occasional missing places in the beds of that formation. If by the action of the river the section is kept clear, so as to remove the drift, this bed of clay can be seen lying with distorted and dishing strata in these intervals The strata are sometimes not preserved, but the masses appear as if thrust into the excavation in the Shakopee limestone, and are very sandy. In other cases the clay seems to have been shaped in layers conformable to the surface of the Lower Magnesian, but unconformable with its bedding. At one place the following section can be made out:

Section in Rapidan, Blue Earth Co.

No. 1.	Alluvium..........................	15 feet.
No. 2.	Irony crag and impure iron ore........	2 "
No. 3.	Greenish bedded clay.............	2 "
No. 4.	Strata of Shakopee limestone, more or less stained and encrusted with iron..................................	4 "
	Total..................................	23 feet.

These parts are arranged, relatively to each other, according to the annexed diagram:



The white sand which here is supposed to belong to the St. Peter, but which may belong to the Cretaceous, is in some way associated with this iron ore. It seems to lie in patches, sometimes just below the iron, and in other places where the iron is wanting. It seems to lie above the clay or shale (No. 3 of the section), its position being the same as that seen at St. Peter.

At other places, a little above the point of the foregoing section, the iron and sand are found irregularly mingled.

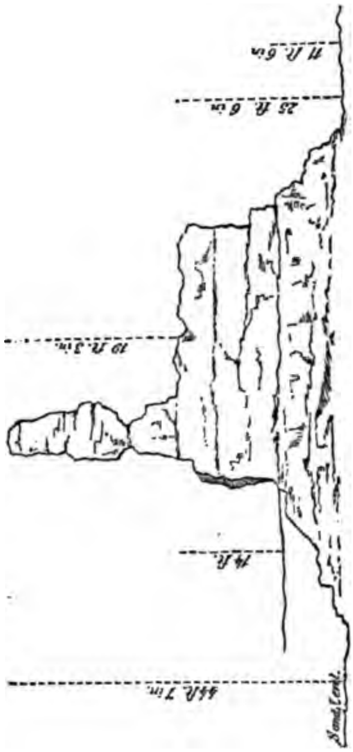
Lone Rock, Sec. 11. T. 114. R. 19. Dakota Co.

strata, 5 to 10 degrees, near the north end, toward the south; besides irregularities of sedimentation that greatly resemble dip. The rock rises in the form of an interrupted ridge, running north and south, and extends about twenty-five rods. The height from the surface of water standing in a little excavation on the northern flank of the bluff, to the base of the bare rock is 12 feet 4 inches, measured by Mr. Furber, by Locke's level; from the lowest rock seen to the top of the rock is 40 feet 11 inches, by the same. There are indications on the top of the rock that the formation did not extend much higher. The grains are coarser, and the lining cement is more abundant. The weather has also caused it near the top to show thin beds of one half to one and a half inches. The rock is about 20 feet wide at the northern end, but tapers to two or three feet; then swells out in a sort of zigzag ridge, and after one or two interruptions, disappears under turf on which grow shrubby oaks. The southern extremity is rocky again like the northern. The dip mentioned only shows at the northern extremity of the ridge. In the valleys about, the drift prevails, and boulders may be seen. The adjoining diagram shows the form and winding contour of the ridge.

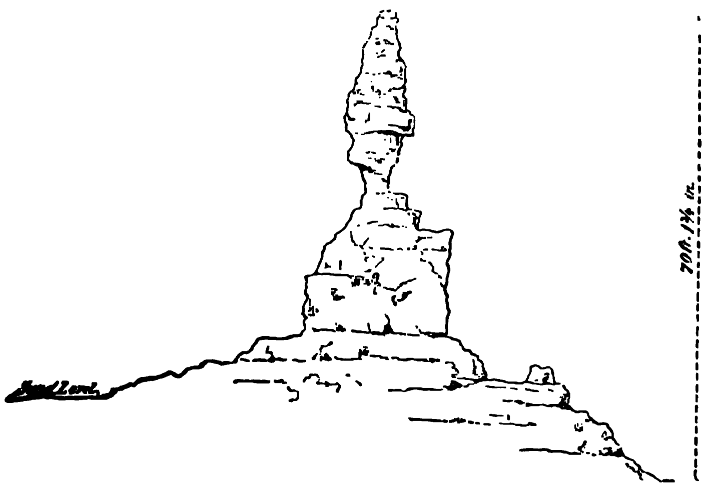
Another of these outliners is known as Castle Rock. It is situated in sec. 32, T. 113, N., R. 19 W., Dakota county. The following diagrams show the elevation and aspect of this rock from the west, south and south-east :*

*Featherstonhaugh gives a wood-cut of *castle rock*, drawn by a "traveler" who had visited it. He locates it near the sources of Le Grand Gres river, supposed to be Sand creek.

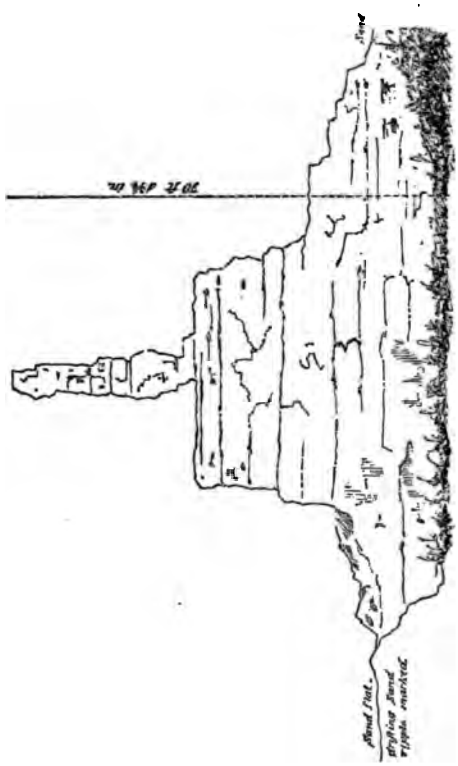
View of castle rock from the west.



View of castle rock from the south.



View of castle rock from the south-east



There is another exposure of the St. Peter on sec. 22, T. 114 N., R. 19 W., about a mile and a half west of Empire City, in Dakota county, within the river bluffs of the Vermilion, and on the north side of the immense slough that lies on that side of the river. It is somewhat quarried for foundation stone. The beds exposed are under about two feet of drift, and about twelve feet above the level of the slough. They lie horizontal. This indicates that the whole valley of the Vermilion, at that point, where it is said to have its greatest width, is wrought in that sandstone.

(d) THE SHAKOPEE LIMESTONE.

This limestone belongs to the great Lower Magnesian formation and is the uppermost member of it. In ascending the Minnesota valley its first outcrop is seen at Shakopee, in

Scott county, where it is wrought for quicklime. It is again exposed at Louisville, in the same county, five miles above Shakopee. A short distance above Louisville it recedes from the river, and the underlying sandstone, seen at Jordan, comes to the surface with a gentle dip to the N. or N. N. E., forming the "little rapids" in the river, and affording a useful building-stone at the quarries at Jordan. In turn this sandstone, by the same dip, is driven back from the immediate valley, and a lower limestone is seen, as at St. Lawrence, having different physical characters, yet belonging to the great Lower Magnesian.

At Ottawa and Kasota, as also at St. Peter, the Shakopee limestone has returned. It thence continues in the valley of the Minnesota, sharing its banks with the underlying Jordan sandstone, to Mankato, where a fine exposure of the beds of both may be seen. As the river there changes its direction it soon passes away from the area of the Shakopee limestone, although there are several fine outcrops on the Blue Earth, and on its tributaries the LeSueur, the Cobb and the Maple, as far south as the township of Rapidan. It is also exposed on the Watonwan, at Garden City, and gives rise, as at other places in the same township, to valuable mill sites.

This, in general, is the course of the Shakopee limestone. It has formerly been supposed to represent the whole of the Lower Magnesian, or For. 2 of Dr. Owen. Its thickness is about 70 feet. The underlying sandstone is about 50 feet thick. The thickness of the next member of the Lower Magnesian has not yet been made out. It is visible at St. Lawrence, in Scott county, and at Judson, in Blue Earth county. This, it will be observed, is not in keeping with the age given the Jordan sandstone by Dr. B. F. Shumard. He referred the sandstone at *little rapids*, and that underlying the limestone at Mankato, to For. 1, of Dr. Owen's series, which he made the equivalent of the Potsdam, of New York. The Lower Magnesian, however, in the bluffs of the Mississippi, at Winona, and at other points, is over two hundred feet thick. In approaching St. Paul its thickness grows no less. It would be a singular phenomenon, to say the least, if at Shakopee, less than forty miles from Hastings where it has its full development, it should have become reduced to less than seventy-five feet. The existence of a heavy, calcareous formation below the Jordan sandstone, demonstrated by the observations of the past season, as detailed in the following pages, proves beyond all question

that the Jordan sandstone has been erroneously referred to the Potsdam age. The Shakopee limestone also maintains a distinct horizon in passing to the east. It was seen, in the season of 1872, at Quincy, in Olmsted county, and was mentioned in the report of progress for that year (page 82).

This assignment of the Jordan sandstone to the great Lower Magnesian formation is, on the other hand, in harmony with the reports of the Missouri geologists who describe that formation as made up of a series of alternating, yet constant, calcareous and arenaceous members. To what extent the lower part of the Lower Magnesian may be thus subdivided, and whether it corresponds to any extent with the Missouri subdivisions, it is not now possible to say.

Section at Shakopee, in Scott county.

No. 1.	Can hardly be separated from the rest, but seems more shattered and thinner bedded. It also contains some chert. It is crystalline and porous, with no regularity of bedding	6-8 feet
No. 2.	An irregular layer of sandstone, or of very sandy limestone, used for building-stone, making some good faces; beds about 8 inches	2 feet
No. 3.	Rather heavier beds of hard gray limestone, of a magnesian texture and feel. These beds are sometimes cracked and checked in all directions, and pass into fine-grained patches, and then thicken again. These thin beds are not infrequently wavy or contorted within the mass. Purgatories are also common in the face of the bluff through all the parts	10-12 ft.

Section at Louisville, Scott county.

The quarry of Mr. G. Baptiste Contre shows a much disturbed and shattered condition of the layers, with frequent green stains as if of carbonate of copper. No constant general section of the bedding can be given, but the lower eight or ten feet are of a reddish color and in heavier beds. This quarry shows very evidently the effect of volcanic upheaval or disturbance. In general it bears a close resemblance to the stone seen at Shakopee. Twenty feet, more or less, can be seen. The quarry is in a bluff or terrace, facing the river, yet is separated from the river by another terrace of the same height, made of the same layers of rock, facing away from the river. This latter rises as an island, about 30 feet above the river bottom.

The same rock is more or less exposed in the road from Shakopee, for a mile, before reaching Louisville. At Shakopee—and the same is true most of the way to Louisville—

this limestone is the cause of a distinct terrace, which rises about 20 feet above the bottoms. On the surface of this terrace a great many boulders of northern origin, often remarkably large, are strewn, the close proximity of the rock preventing them from disappearing in the thin alluvium. As the direction of the river seems not to coincide with the direction of the strike of the limestone, it soon passes on to the belt of the sandstone seen in the *little rapids*, and at Jordon, the transition from the former stone to the latter being indicated by a change in the character of the river bluffs, and the terrace already mentioned. A short distance below the mouth of Sand creek the limestone affords an exposure in the right bank of the river, while the creek itself is on the sandstone. The sandstone there is the only rock visible in the river, as far as to St. Lawrence, which is in T. 114, R. 24, Scott county. The limestone there exposed lies below the sandstone, and will be described in another place. With the exception of a slight exposure a mile or two below Belle Plaine, and another near Blakeley, the rock is not seen again on the east side until reaching *white rock bluff*, at Ottawa. On the west side about a mile below the Jessenland church (sec. 13, T. 113, R. 26) there is a low outcrop of the lower limestone in the river bottoms.

At Ottawa, in Le Sueur county, the Shakopee stone has fully returned, and affords a very fine outcrop, rising, with the underlying sandstone, to the hight of about 70 feet above the river, and causing as at Shakopee a broad terrace, on which the village stands.

Sections at Ottawa, Le Sueur county. (a) Quarry of John P. Rinshed.

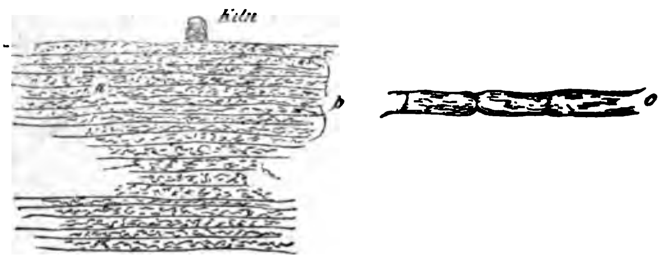
No. 1.	Fawn-colored, arenaceous limestone in even beds that correspond in undulations with the upper surface of No. 3	4 ft.
No. 2.	Sandstone with a calcareous cement; of a lighter color, and corresponding in undulations with the surface of No. 3	2 ft.?
No. 3.	Magnesian limestone, very much like the Shakopee stone, holding green clayey deposits: in lenticular and irregular beds; the surface, freshly uncovered by the removal of the beds of No. 2, has much the appearance of being weathered, rising and falling at gradual angles and causing the overlying members to have corresponding undulations. Not well seen here. Said to be........	8 ft.
	Total........	14 ft.

Other quarries showing nearly the same composition of layers as Rinshed's, are owned by Levi Case and Charles Schwartz.

(b.) At Rinshed's lime-kiln.

Nearer the river, at Rinshed's kiln, the underlying sandstone can be seen. In this section there is exhibited either a fault or an instance of unconformability in the bedding. The relation of the sandstone to the limestone may be best exhibited by the following diagram:

Diagram showing the relation of the limestone to the sandstone, at Ottawa, Le Sueur county.



Explanation.

a. Horizontal layers of white crumbling sandstone showing oblique sedimentation; sedimentation undisturbed, seen 25 feet.
b. Interval of ten feet hid by debris.
c. One bed of fawn-colored limestone, almost free from sand; lies below the stone of Rinshed's quarry, 2 feet.

About ten rods below this kiln, near another old kiln built by excavating in the sandstone along the bluff, the following section may be seen:

(c) Ten rods below Rinshed's lime-kiln.

No. 1.	Lime-stone, fawn-colored, in undulating beds; beds two or three inches or as thick as one or two feet, apparently disturbed	15 feet.
No. 2.	Sandstone, as at Rinshed's kiln, undisturbed, seen	25 feet.

Just back from the bluff where the last section was taken, is the opening that furnishes stone for the kiln. The limestone here appears like that at the bluff.

The whole of these exposures make up, in general, one irregular stratum of limestone, with sandy patches and layers occurring indiscriminately, and should not be divided generally into different members. The sandstone underlying, however, has an uneven upper surface, due perhaps, to the violence of the latest sedimentation, instead of upheaval,

before the disposition of the limestone. There is no other way except that of supposing a fault, or an instance of unconformability within the Lower Magnesian, to account for the position of the heavy bed of limestone exposed so far below the top of the sandstone at Rinshed's kiln.

A little more than a quarter of a mile below Rinshed's kiln, a little ravine crosses the beds, showing the upper portion of the sandstone, as follows:

(d) *Section in the sandstone at Ottawa.*

No. 1.	Red, hard sandstone, in one heavy bed, exactly like that in the cut on the Sioux City R. R. near Louisville..........	1 foot.
No. 2.	White sandrock, like that in the railroad cut near Louisville.......... seen	2-3 feet.

The observations made at Ottawa throw much light on the relation of the limestone there with that at Shakopee, thus—

Shakopee limestone=Ottawa limestone.
Louisville kilns....=Ottawa kilns.
Jordan sandstone...=Ottawa sandstone.

At St. Peter the quarry near the asylum exposes the uppermost layers of the Shakopee limestone. Owing to the work going on in the finishing of the asylum building, a fine opportunity is here afforded for seeing these beds in their best estate. The beds are here very regular, differing very much from the thin and confused bedding at Shakopee, and in the deep openings they seem to be all very heavy. Indeed, in the face of the quarry the bedding can hardly be discovered. It seems almost massive. Yet on quarrying the stone it parts along certain horizontal planes that must be bedding planes. Some faces show five feet. Other beds are two, and three, and four feet. The upper four feet are checked into beds of two to four inches by the weather. It is rather darker, when first quarried, than the Kasota stone, but has the same general cast of color. It seems sometimes to have a brownish tinge. The amount seen here is about twenty-five feet.

In the banks of the river at St. Peter, the sandstone, corresponding to that already described at Ottawa, can be seen, forming perpendicular or overhanging bluffs fifteen feet or more in hight.

On the terrace formed at St. Peter by these rocks, other

quarries have been opened by Albert Knight, and by others, but none exhibit the characters of the formation so fully as that at the asylum.

Across the river from St. Peter, and about a mile toward Kasota, is another exposure of the limestone, in a bluff along the roadside. It seems here to be more shattered and irregular, and like the Shakopee stone. Lime burned near here cannot be distinguished from the Shakopee lime. About eighteen feet are seen, the lower part being in good heavy beds. The upper surface is waterworn, and in the openings the Cretaceous has been deposited.

Geo. C. Clapp's lime kiln and quarry are five miles below Makato, on sec. 17, township of Kasota, within the main drift bluffs of the Minnesota, but on the terrace formed by the Shakopee limestone, and about a mile from the river. His quarry, located near his kiln, exposes a fine gray limestone, about two feet thick, sometimes less or more, graduating into the Shakopee stone which underlies. It is very firm, little porous, and contains *Orthis*, at least, and affords the finest and purest limestone hitherto seen in the Shakopee stone. It must be regarded as the upper portion of the Shakopee. This fine, compact texture, and gray color, are not continuous in the same horizon, in other places the harsh magnesian grain and arenaceous quality existing in the same beds. Running along the river for several miles, sometimes touching the river and sometimes exposed back of islands that show the same, this limestone forms a bluff of solid beds. Although there is usually a heavy talus covering the foot of this bluff, yet at several points the identity of this horizon with that at St. Peter, and hence with that at Shakopee, is fully established by the exposure of the underlying sandstone. It is seen at a point about two miles below Mr. Clapp's farm. This bluff shows a good stone, as at St. Peter and Kasota, but is not much quarried. Perhaps it is more arenaceous in patches. It is blotched with whiter spots, and with soft chert.

Another fine exposure of this geological horizon is visible about a mile and three-quarters below Mankato, on the same side of the river. The place here referred to is that sometimes known as *hurricane bend*, although the point so named by steamboat captains is said to be about four miles further down the river. The section here exposed is the same as at Clapp's, and also the same as at Makato, but here there is an observed thickness of sandstone amounting to forty-five feet, somewhat hid by debris. This equiv-

alency is unmistakable, since the bluff can be traced nearly all the way to Clapp's, and since between here and Mankato, besides the continuance of the same surface features—the wide, stony prairie formed by the terrace, the uniform altitude of the terrace, and its striking similarity to the terraces at St. Peter, Kasota, Ottawa and Shakopee—the actual continuity of the formation can almost be traced out by exposures of the rock.

In the report of progress for 1872, the section at Maxfield's quarry at Mankato was given (p. 83) covering 61 feet of the Shakopee limestone. The further examination of this locality, and of the river bluffs for several miles below, during the season of 1873, makes it desirable to unite the sections observed in one general section, as follows:

Section at Mankato, in Blue Earth county.

No. 1.	Porous magnesian limestone, not used	4-6 ft.
No. 2.	Coarse, friable sandstone	2-4 ft.
No. 3.	Magnesian limestone burned for lime	2 ft.
No. 4.	Calciferous sandstone, in heavy beds, of various grain and texture, sometimes mottled, quarried for building	30 ft.
No. 5.	Upper shale bed, arenaceous and mottled with red	2-3 ft.
No. 6.	Calciferous sandstone, generally used as a cut-stone, compact and even grained	4 ft.
No. 7.	Rough and irregular magnesian limestone, somewhat arenaceous, but unfit for cutting	10 ft.
No. 8.	Lower shale bed; very much the same as the upper	2 ft.
No. 9.	One heavy bed, generally good for cut-stone	3 ft.
No. 10.	Irregular and sandy bed; more or less cavernous and porous, its lower three or four inches in thin chips, fine grained, and stained with iron	3 ft.
No. 11.	Jordan sandstone, seen about	45 ft.
	Total of the Shakopee limestone, about	65 ft.

From Mankato toward the mouth of the Blue Earth river, the Shakopee limestone is seen at frequent places, forming precipitous mural faces, capping the underlying sandstone; the two united making bluffs that rise from seventy-five to a hundred feet. These exposures are mostly on the right bank, but there are also elevated islands in the river, or at least elevated portions in the area of the bottom land, that present similar perpendicular rocky bluffs on one or more sides. These exposures extend somewhat beyond the mouth of the Blue Earth. The Blue Earth has cut its passage through this rim of rock, at the point of its debouchure upon the Minnesota bottom land, and on its right bank, at the place of the crossing of the St. Paul and Sioux City R. R., a series of interesting observations were made. Before

reaching this point, however, in following the highway from Mankato to South Bend, but on the east side of the bridge over the Blue Earth, the Shakopee limestone is exposed in a recent excavation by the side of the road, in the removal of the Cretaceous clay, which is seen there to overlie it unconformably. The limestone here shows the effects of long exposure to the weather, and the action of water in the form of waves, probably those of the Cretaceous ocean, prior to the deposition of the clay. A much better example of the same effects may be seen a little further south, just before the crossing of the Blue Earth by the Sioux City R. R., where the grade is cut into the rock for several rods before reaching the river. The old Silurian surface is here very much weathered, and coated with iron peroxide, the nooks and openings, and all sheltered places being filled with the fine, plastic but bedded greenish clays of the Cretaceous age; the drift gravels and sand overlying both. These phenomena are alluded to again and more fully discussed under the head of the Cretaceous.

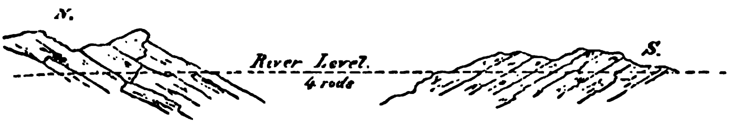
Passing from the mouth of the Blue Earth south, towards the Red Jacket flouring mills, occasional exposures of the Shakopee stone are met with along the highway and in the railroad cuts (Minn. and Northwestern R. R.), for about three miles. The Red Jacket mills are on the Le Sueur river, four miles south of Mankato.

On the Maple, near its union with the Le Sueur, in sections 11, 12 and 13, township of Rapidan (107, 27,), Blue Earth county, quarries that are feebly run, are owned by Barney Simmons. Samuel Michael, and by Messrs. Averill, Culver. Wood and Allgrain. These quarries reach about two miles above the mouth of the Maple, and are in the same horizon as the Mankato quarries. The stone occurs in horizontal, heavy beds. along the low banks of the river, exposing 25 or 30 feet. Some mention has been made of the Shakopee stone at this place in describing the sandstone there seen to overlie it, and supposed to be the St. Peter. (See p. 133).

The Shakopee limestone is exposed at Garden City, in Blue Earth county, in the banks of the Watonwan river. Mr. S. M. Folsom owns a slight exposure which is somewhat worked, situated in the low bank of the river, near the water. At the mill dam, just above the highway bridge, it may be seen, exposed in a rough and very irregular outcrop, in the midst of the river, forming a rocky island. It here

presents large cavities, and sometimes a breccia. The beds are thick, and lie in a short synclinal, as illustrated below.

Synclinal in the Shakopee limestone, at Garden City, in Blue Earth county.



This synclinal is not believed to be anything that affects the general dip of the formation, but an illustration of the irregularity that it sometimes presents in its bedding. A similar phenomenon was noted in respect to this limestone, at Ottawa, in LeSueur county. It is a structure very common in the Waterlime, of the Upper Silurian, seen in northwestern Ohio.

This exposure of the Shakopee limestone has very much the general character seen at Shakopee. In the roughened upper surface the usual gasteropod, seen also last year at Rochester, in Olmsted county, was seen at Garden City, (*Euomphalus.*)

(e) THE JORDAN SANDSTONE.

This name is here applied to that member of the Lower Magnesian which immediately underlies the Shakopee limestone. As has already been stated, it has been referred by Dr. B. F. Shumard to the Potsdam sandstone or formation 1, of Dr. Owen's series. The observations of the past season have disclosed the fact that it is only about fifty feet in thickness, and is underlain by another great limestone formation which, while it differs considerably from the Shakopee stone, is still a magnesian limestone, and belongs to the same great series.

This stone is first seen in ascending the Minnesota valley, so far as at present known, at the "little rapids," near the city of Carver, in Carver county. It here causes a fall of about seven feet, divided between two separate rapids. The lower rapid has a fall of about four feet. The upper is about half a mile further up. The stone is thick bedded and coarse-grained. A few rods above the upper rapid it is exposed in the right bank, showing about six feet in nearly horizontal beds. This sandstone was penetrated in sinking

a well at Louisville, after passing through the Shakopee limestone, the thickness of over twenty feet. Passing along the public road from Louisville to Jordan, the strike of the sandstone can be seen by outcrops, in the form of stony islands, in the river bottoms, and by exposures near Dooleyville. Where the public road crosses "Van Oser's"* creek, a short distance above Dooleyville, it has a dip of 10 or 15 degrees toward the W. N. W. About twenty-five feet can here be made out in passing along the stream from a short distance above the road to the crossing of the St. Paul and Sioux City R. R. It is in heavy beds and is coarse-grained. It is full of seams and checks, presenting some appearance of dip in different directions. Some of the seams, or lines of apparent bedding, run nearly perpendicular, but they do not have a constancy that shows dip. The operation of the stream is such as to bring out the bedding, by the wearing away of the softer layers, so as to indicate dip in the direction already stated.

Near the railroad bridge over Van Oser's creek, and in the public road, this sandstone is conglomeritic and broken. It shows the effect of heat. The bedding is disturbed and even fractured, the openings having been again filled with coarser materials and some pebbles. Some parts of it are highly ferruginous, so as to make an impure iron ore which is black. These characters, however, are confined to a very small area, not being seen over more than three or four square yards, making a mound-like prominence that rises two or three feet above the level of the rest of the bedding, which is bare for some rods about.

About a mile above the crossing of Van Oser's creek, the St. Paul and Sioux City R. R. cuts through sandstone which may be somewhat below the beds last mentioned. The upper part of this may be regarded as belonging in the section at the creek. This cut is composed of the following parts:

No. 1.	Hard (yet within friable) sandstone, in one bed, of a reddish color, which resembles the color of the Shakopee stone near the bottom of the section at Louisville.....	3 ft.
No. 2.	Fine, incoherent, white sandrock, massive: seen five feet, may amount to..................................	10 ft.

Directly east of this cut, across the public road, No. 1 above, which is supposed to be the same as the sandstone seen in Van Oser's creek, outcrops so as to show 15 or 20

* This is corrupted from Van Osterhaus.

feet. It causes a considerable knoll, where huge blocks four or five feet thick are checked loose by the weather and removed from the general mass. This is a favorable place for quarrying.

At Jordan, three and a half miles above this place, this sandstone affords its typical outcrop. It occurs in Sand creek, about a half mile above the village. Quarries here are owned by John Volk, and by Wosanick and Loniacheck. The general section obtainable from the various outcrops along this creek has been described.*

Section at Jordan, Scott county.

No. 1.	Sandrock, buffish, quite ferruginous, thick-bedded, seen at the mill	6 feet.
No. 2.	Sandrock, ferruginous, thin and irregularly bedded, friable and disentegrating, with many ferruginous seams, crusts and concretions. In quarry	3 feet.
No. 3.	Sandrock, irregularly whitish or ferruginous, heavy-bedded, obliquely and beautifully banded with iron streaks and laminae. In quarry	12 feet.
No. 4.	Sandrock, buffish, similar to No. 3, but thinner bedded. In the quarry	8 feet.
No. 5.	Sandrock, hard and ferruginous above, soft, friable and buffish red below. Falls of Sand creek	10 feet.
No. 6.	Sandrock, whitish, compact. In the beer vaults, seen	12 feet.

In the bed of the creek, near the breweries, this stone seems somewhat calcareous. It is of a reddish color and slightly porous, while the quarried stone shows generally a white color, except where irony water has rusted the interlaminations, presenting then a streaked section of rust and white. The bedding in the creek is also thinner. Although the foregoing section makes up a thickness of 51 feet for this sandstone as exposed at this place, the observations of the survey do not warrant the assignment of that aggregate thickness to the outcrops there. Some of the localities named being regarded as on the same geological horizon. The general uniformity of characters makes it difficult to judge how much of the bedding at one place may be included in the outcrop at another; but twenty-five or thirty feet would probably cover the thickness exposed.

The next known exposure of this stone is at Ottawa, where it underlies a considerable thickness of the Shakopee limestone. The geology of this place has been given in treating of the Shakopee limestone. The interesting ob-

**Report of a geological survey of the vicinity of Belle Plaine, Scott Co., Minn.* By Alexander Winchell. In this report the name of *Jordan sandstone* was first applied to this stone, although still regarded as of the Potsdam age.

servation was there made of a local unconformability in the limestone, with the Jordan sandstone. (See p. 141).

From Ottawa to Mankato, this sandstone may be seen at nearly all places where the Shakopee limestone is exposed. It is apt to be somewhat covered by debris, as it lies at the base of the continuous bluffs that these two formations cause throughout that part of the Minnesota valley.

Near the Red Jacket mills, four miles south of Mankato, on the Le Sueur, is an outcrop of sandstone, which is doubtfully referred to the Jordan. It is in the right bank, just above the mill dam. It forms a perpendicular bluff rising from the water about 20 feet, underlying a heavy deposit of drift which rises nearly two hundred feet higher. In the sandstone are soft, apparently magnesio-calcareous pieces, about an inch in diameter, usually flattened, or pointed, or edged, which if dry, crumble to powder in the fingers, revealing little or no grit, but which when wet, are sticky and plastic. These pieces resemble somewhat the thin deposits of shale seen in the sandstone that has been referred to the St. Peter a few miles higher up on the Le Sueur. (See the Report of Prof. Peckham for an analysis of these pieces of shale). This fact in connection with the existence of irony crag in the overlying drift bluff, make the resemblances of this outcrop to the above outcrops supposed to be St. Peter, and to those at Garden City, rather greater than to the Jordan. The geographical and topographical relations of this outcrop, however, cause it to appear very strongly to belong to the Jordan. (See p. 133).

At Cappels mill, on the Watonwan, two and a half miles below Garden City, a sandstone is exposed, and somewhat worked. Its stratigraphical relations are not certain, but it probably belongs to the Jordan.

Three miles below is the Rapidan mill. The same sandstone is exposed at this mill and at several places between these mills.

At Minneopa falls, sec. 21, T. 108, R. 27, the cascade is caused by the Jordan sandstone. The perpendicular fall of the water is about 30 feet, but 45 feet of the sandstone can be made out. Before reaching the point where the water leaps over, the steam works its way through a perpendicular thickness of 15 feet of sandstone beds. It then comes in contact with a harder portion of the sandstone, which has a thickness of about six feet. This resists the water longer than the under lying layers, and maintains a projecting shelf. The mist that rises keeps the walls wet, and the freezing of

a limestone, and very durable, of a flesh color, varying to buff, striped, specked and blotched with green. The sides of the bedding are almost altogether green.

Allusion has already been made to a reddish stone closely associated with St. Lawrence limestone, the geological horizon of which it is difficult to state. The first exposure observed of this occurs three miles above Blakeley, and on the west side of the river, in Jessenland township. It is in the river bottoms, N. E. ¼, sec. 12, T. 113, R. 26, owned by Mr. D. Doheny, who has opened a little quarry. It is a red, metamorphic limestone, nodular, concretionary, and filled with checks and planes of separation, the thickest beds being not more than four inches, the most of them less than two, and more or less contorted. It has greenish surfaces, and isolated pockets of fine, apparently copper stained materials, but very sparsely disseminated. It is almost a worthless stone for any use except macadamizing, owing to the ease with which the beds are fractured transversely. It is rough and irregular. It is fine-grained generally, rarely porous, and cryptocrystalline. When weathered it shows an arenaceous composition. It is seen in surface exposure over several square rods, the thin red chips covering the ground. About six feet of bedding may be seen. The position of this limestone is supposed to be somewhat above that seen at St. Lawrence, and below the Jordon sandstone. It perhaps has not characters sufficiently defined and constant to be separable from the St. Lawrence. Indeed there are some good reasons for supposing it may be the uppermost portion of that limestone considerably charged with iron, and changed in outward appearance by the waters of the valley.

(g) THE ST. CROIX SANDSTONE.

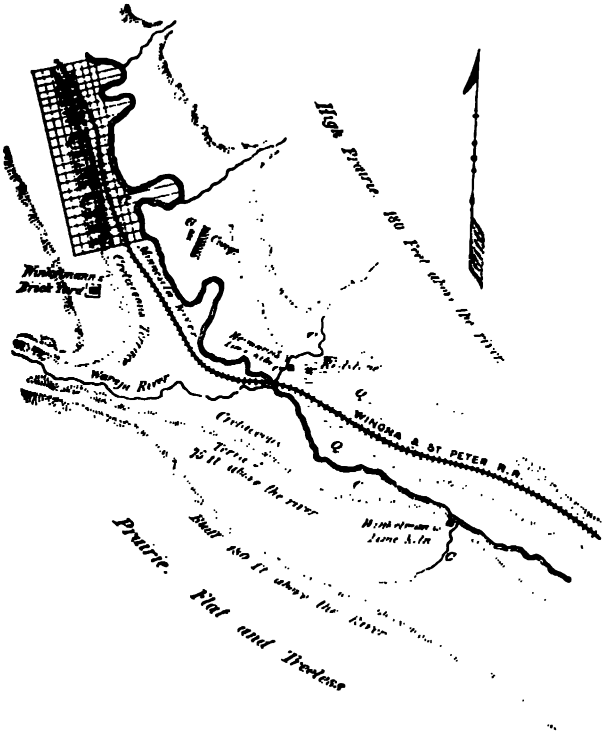
In the report of progress for 1872, this name was provisionally applied to the light-colored sandstones exposed largely on the upper Mississippi and on the St. Croix rivers, lying immediately below the Lower Magnesian. During the season of 1873 no observations on this series of sandstone have been made, and no new light can be added to the question of the age of those beds, except what may be found in connection with the description of the outcrop of red quartzite at the mouth of the Waraju river, near New Ulm.

(h) THE POTSDAM SANDSTONE.

This name is here applied to the red sandstones that lie below the light colored sandstones of the upper Mississippi valley, and to their supposed equivalents in the southwestern part of the state. The principal observations on this sandstone made during the season of 1873, were upon the outcrop near New Ulm. The annexed map of this locality will give a correct idea of the position of this outcrop in respect to the outcrops of conglomerate and granite which occur a short distance further up the river. A careful observation on the dip of the quartzite, south of the railroad cut, corrected for variation of the needle, gave 27° N. 10° E. A similar observation on the conglomerate gave a dip of 18° toward the E. S. E. The granite outcrop is located on the authority of Dr. B. F. Shumard, who says: "The granite is a hundred yards removed from the conglomerate, with its line of elevation running nearly parallel with the latter. Flesh-colored feldspar makes nearly two-thirds of the granite." This outcrop of granite was not noticed by the survey in examining this locality.

Map of the vicinity of New Ulm and Redstone, showing the position and dip of the conglomerate and quartzite

Scale one inch = one mile



Explanation.

c. Cretaceous outcrop; beds horizontal.
g. Granite outcrop.
cong. Conglomerate outcrop; dip 18° E.S.E.
q. Red quartzite outcrop; dip 27° N. 10° E.

The dip of the quartzite varies in degree. It is greatest near the river, and is least near the northern extremity of the exposure. Indeed, near the northern extremity the surface has a slope which is apparently due to dip, in the opposite direction. A section north and south through the quartzite would show dip changing somewhat as illustrated by the following diagram, sketched on the spot:

Dip of the quartzite at Redstone.

At the northern extremity of the exposure the surface of the rock shows a coarser grain, becoming almost conglomeritic. No true conglomerate can be here seen, but there are grains of white quartz as large as a mustard seed disseminated through it. The relation of this coarser portion to the rest of the quartzite is such as to cause it to *overlie* the most of the quartzite, but its actual superposition cannot been seen. In some of the thin bedding near the lowest part exposed, mica scales are visible on the planes of the bedding. When fresh they are black, but if weathered they are of a golden yellow color.

In many places there are evidences of a higher stage of the Minnesota at some earlier time. These consist of furrows and water-worn surfaces. There are some pot-holes, worn usually so as to have their elongated dimension in the direction of the river, their shape being generally oval. One of the largest noticed was 20 inches long and 15 inches wide. Its depth was 24 inches. These water-marks rise 120 or 125 feet above the river.

On the north side of the river, nearly opposite New Ulm, is an outcrop of coarse jaspery conglomerate, the pebbles in which are occasionally a foot in diameter and waterworn. There are also white quartzite pebbles. Ten feet may be seen, in an irregularly descending strike nearly north and south. The strike of this conglomerate outcrop is conspicuous in the woodless prairie, or terraced slope from the prairie. It rises from the very river bottoms and enters the bluff diagonally at a hight of perhaps 50 feet above the river. The talus hides the underlying stone. The strike faces up the river.

The quartzite outcrop at New Ulm was described in general the report of progress for 1872 (p. 75). The degree of dip and the thickness of the bedding exposed were, however, over-estimated. There may be 250 feet of stratification exposed, and the hight of the rock does not exceed 125 feet above the river.

The following is Dr. E. Emmons' description of the "sandstone of Potsdam," taken from his report on the sec-

ond geological district of the state of New York, printed by the Legislature, in January, 1838.

"I shall not enter upon its geological relations, any further than to state, that in Potsdam, and other towns in which it appears, it uniformly rests on the primary strata; and in no part of the country is there any rock which interposes itself between it and the primary, so that it appears here as the oldest repesentative of the transition series. The identification of this rock with the sandstones along the southern border of lake Ontario, will be a matter of some difficulty. It is geologically below the transition limestone, and never in the northern district alternates with it, but always holds the relation of an inferior rock. So much is known of its position, but still some doubt remains as to its general relation, and to its name and place in the series of rocks. Some call it the old red sandstone; others regard it as equivalent to the new, or saliferous rock of Eaton.

* * * * * * *

"This rock is a true sandstone, of a red, yellowish-red, gray and grayish-white colors. It is made up of grains of sand, and held together without a cement. Intermixed with the siliceous grains are finer particles of yellowish feldspar, which do not essentially change the character of the sandstone, but they show the probable source from which the materials forming it were originally derived, viz., some of the varieties of granite. Unlike, however, most of the sandstones, it is destitute of scales of mica. The coloring matter of the rock is evidently oxide of iron, but unequally diffused through it, giving it intensity or deepness of color in proportion to its quantity. In some places it is almost wanting, which makes it, when pulverized, a good material for glass. The grains and particles in its composition are generally angular, but where it takes the character of a conglomerate, as it does in the inferior layers, they are frequently rounded. The thicker strata exhibit an obscurely striped appearance, owing to the prevalence of certain colors in the different layers."

Quartzite similar to that described at Redstone was again seen in the southern part of sec. 7, T. 106, R. 36, on land belonging to the St. Paul & Sioux City R. R. It presents here a small surface exposure, in a ravine, without exhibiting any distinct bedding. Its surface is glaciated in a direction, corrected for variation, S. 34° E.

At another point, perhaps in the edge of the next section west (12), is a larger exposure of this quartzite. The

dip is 4° or 5° N. 10° W. The stone is very hard, but banded with light and red beds, evident on the planed surface and on the fractured side. This point shows glaciation S. 30° E. (corrected for variation). There are other smaller exposures further west a short distance. They occur frequently on the hillsides, where the drainage has washed off the light drift which contains a few boulders.

At still another point, in the same section, the glaciation is very evident. There is here a trench, traceable across the whole extent of the exposure, a distance of several rods, which does not perceptibly vary in direction. It is a foot across, and two inches deep, and its direction, corrected for variation, is S. 32° E.

There is an extensive and important ridge of this quartzite not yet visited, about in the northern part of T. 108, ranges 35, 34 and 33, situated between the Big and Little Waraju rivers.

Mr. I. J. Rochussen is authority for the location and further items of other outcrops of this red quartzite. It may be seen, according to his description, on the edge of the valley of Rock river, in Rock county, three miles north of Luverne. It consists of a ridge three miles long, running N.E. and S.W., so far as known, its average height being 25 or 30 feet. The beds lie nearly horizontal or show a very slight dip, and are from one to four feet in thickness, and rather easily quarried. Also on the road to Sioux Falls, 15 miles west of Luverne, and two and three miles west and northwest of a settlement known as Valley Springs, are a number of outcrops, one large, isolated piece being known as *lone rock*. It is quarried at one point, and there shows conglomerate. At Sioux Falls, 15 miles further west, in Dakota, the same rock forms the fall, and lies in heavy layers nearly horizontal. The aggregate fall is 120 feet.

(i) THE GRANITES OF THE VALLEY.

The following account of the granites of the Minnesota valley will consist of a location of outcrops, and a description of their physical, outward characters. No attempt will be made to classify them, or to refer them to any horizon of rocks exposed in the northern part of the state. There has not yet been sufficient time to engage in mineralogical or chemical comparisons with the northern granites. There is no hesitation in saying that they are a southwestward exten-

sion of those northern granites, and that their parallelisms probably exist and that they can be referred to their proper places, when a sufficiently detailed examination of the state shall have been made.

With the exception of the small exposure of flesh-colored granite near New Ulm, mentioned by Dr. B. F. Shumard, the first outcrop of rock of this kind occurs in ascending the valley at "La Framboise place," where it rises seventy-five or a hundred feet above the level of the river. This is at Little Rock creek, about four miles below fort Ridgely. The exposure has long been known among the French traders as La Petite Roche. It is one of a series of exposures in the same vicinity, extending along the river bottoms, mainly on the north side, for a mile or two. In general this rock is granite. It rises in low knolls, perhaps 50 feet above the flood plain, visible from the "state road" that skirts along the foot of the bald drift bluffs on the north side of the river. Its outward appearance is that of a reddish granite, made up of the ternary granite compound, the separate grains of which are not coarse, the largest ones being the feldspar. The quartz is milky, or often amethystine; the mica is rather scarce for typical granite, and the feldspar is red or flesh-colored. The red color greatly predominates, giving a reddish tinge to the whole stone, wherever the weathered surface is kept free from lichens, or where the interior is freshly exposed by cuts for quarrying. The drift bluffs are not at all affected in contour or direction by these granite knolls, although the river itself winds about in the lowest channel accessible. No regular dip is distinguishable. The granite shows an abundance of seams and divisional planes, in various directions, that make it presumptuous to say which way the original bedding may have lain. The only circumstance that indicates the direction of dip is the occurrence of the most abrupt faces, in numerous places, on that side toward the river, the opposite slopes being more gradual, descending gently toward the north, as if the horizon of bedding sloped in that direction at an angle of 35° or 40°.

On close inspection of this granite with a pocket-glass, there seems to be much uncertainty about the color of the feldspar. The reddish color is most prevalent outside of the feldspar crystals, or only on their surfaces, as if the stain arose from rustiness and weathering, and had permeated the loosened granular mass by being in solution in water. There is a powdery, at least a gritty and sandy cement,

which fills the interstices within the mass and between the grains of quartz and the crystals of feldspar, that seems to be generally redder than the distinct quartz or feldspar portions. Yet that loose and more finely pulverized part seems to be made up entirely of quartz, appearing, on close examination, to have the light color and distinct fracture of glassy quartz, the red color vanishing from sight. The color seems to be located very largely in the cement, as in the red quartzite at New Ulm, suggesting the query whether this may not be more highly metamorphic sandstone. In a deep fracture, however, the red color is much less observable, being replaced by a gray, the feldspar grains becoming more evident, and the whole rock appears much like the St. Cloud granite.

Above fort Ridgely, by following the only passable road, a number of granite outcrops were not seen. At a point two miles below the Lower Agency, T. 112, R. 34, sec. 10, Mr. Wm. H. Post lives on the bottoms, near the mouth of a little creek coming in from the north. From him the following statements of granite in the bottoms above fort Ridgely were derived. It outcrops much more frequently on the south side than on the north side of the river. Throughout the whole distance to the fort (10 miles) occasional mounds of bare granite rise up in the bottom land. But these exposures are often quite small and at some distance from the river. At Marshner's carding factory, seven miles above the fort, are a number of granite knobs, in the vicinity of a lake situated in the bottoms. Half a mile further up is another exposure, but more or less connected, by smaller exposures, with that at Marshner's. The next principal outcrop between fort Ridgely and Mr. Post's, is on the south side of the river, and is visible from his house. It shows a conspicuous bared spot, with some timber, rising in one place nearly as high as the enclosing bluffs, but not effecting the general level of the prairie, unless it be in causing, as has been observed in one or two other places, a knobby or rolling tendency in the prairie surface, with gravel and boulders strewn over the surface of the knolls. One very prominent rock rises nearly forty feet above the general level, cone-like, and can be ascended only on one side. It bears a few cedars.

At Mr. Post's, granite outcrops occur at two places in the bottoms. These rise but a few feet above the general level. This granite has a strong resemblance to that at La Framboise's. It contains but little mica, and the feldspar is flesh-colored. The color here penetrates the feldspar crys-

tals. In some places, however, the mica is more abundant, and the feldspar is less red.

Birch Coolie creek joins the Minnesota in sec. 5, T. 112, R. 34. The sides of this ravine, a short distance above its mouth, are in granite, which is more or less decomposed. It seems to have a dip S., SE., and SW. The only place where real granite can be seen is about 30 rods above the mill dam of Mr. Eldridge. It here rises 20 or 30 feet above the creek. In other places the creek runs over it, making rapids and falls, some of which Mr. Eldridge has improved for his mill power.

A substance was met with here for the first time which was afterwards seen at a number of places. Its origin seems to be dependent on the granite. Its association with the granite is so close that it seems to be a result of a change in the granite itself. It lies first under the drift, or under the Cretaceous rocks, where they overlie the granite, and passes by slow changes into the granite. It has some of the characters of steatite, and some of those of kaolin. In some places it seems to be a true kaolin. It is known by the people as "Castile soap." It cuts like soap, has a blue color when fresh, or kept wet, but a faded and yellowish ash color when weathered, and when long and perfectly weathered, is white and glistening. The boys cut it into the shapes of pipes and various toys. It appears like the pipestone, though less heavy and less hard, and has a very different color. It is said to harden by heating. This substance, which may, at least provisionally, be denominated a *kaolin*, seems to be the result of the action of water on the underlying granite. Since it prevails in the Cretaceous areas, and is always present, so far as known, whenever the Cretaceous deposits have preserved it from disruption by the Glacial period, it may be attributed to the action of the Cretaceous ocean. In some places it is gritty, and in others it may be completely pulverized in the fingers. A great abundance of this material exists in the banks of the Birch Coolie, within a short distance of its mouth.

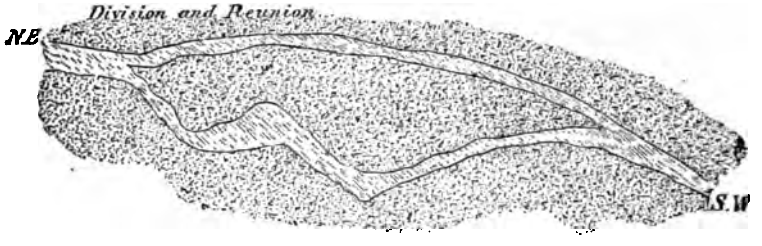
In the bed of the creek, above the mill-dam, several veins are seen crossing the smoothed surface of the rock. In low water these can be closely inspected, and their composition and structure ascertained. The following sketches illustrate some of their interesting features.

The structure of granite veins at Birch Coolie.

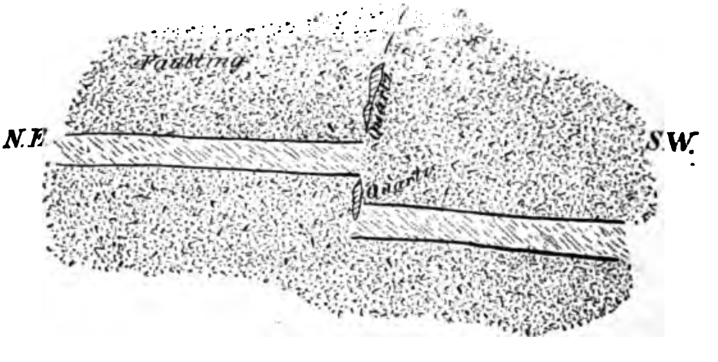
The vein, a part of which is illustrated by figures below, is in granite, and is made up of granite. The constituent

parts, however, in the vein, are much finer, than in the body of the enclosing rock, and show a deeper tinge of red color. Its direction is S.W., and it is four inches wide. It is visible along the creek 250 feet, and it is crossed by numerous other veins that are mainly quartzitic and narrow. The structure of the main vein is somewhat schistose, and seems to be harder, judging from its forming a ridge that stands above the general surface of the rock one or two inches. The laminæ of the schistose vein run usually at some angle across the direction of the vein, but in one place, where is a slight change in the direction of the vein, they nearly correspond with it. Their usual direction is nearer N. and S. This main vein is faulted in several places, and is divided so as to enclose an irregular oblong area at one point. The fault here sketched is accompanied by a very little quartzitic deposit, but there is no constant vein of quartz crossing the main vein, though there is a small indistinct seam that curves off to the south on the east side. The laminæ in the two separated ends of the vein exhibit a curving in opposite directions, as if they had been somewhat elastic or plastic, and by being wrenched apart, had bent toward each other.

Division and reunion of vein at Birch Coolie.

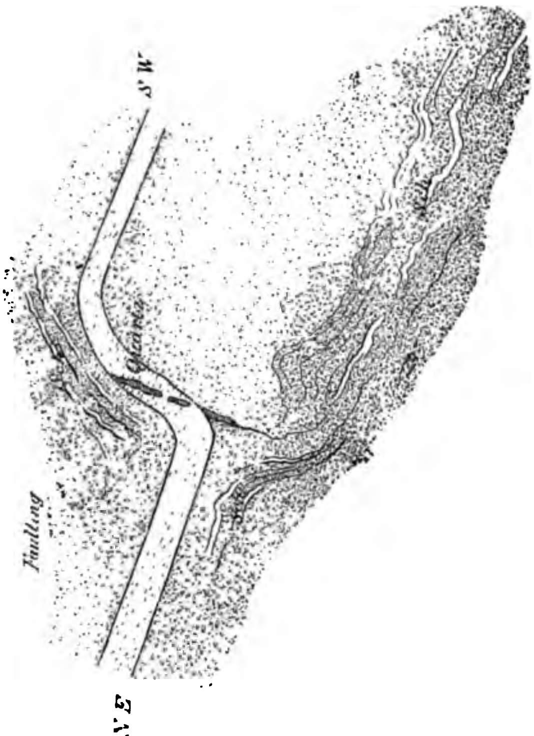


Faulting in vein at Birch Coolie.



The following diagrams represent some of the effects of disturbance in changing the direction and structure of veins. The curvature represented in the first below, is a part of the same vein as described above. It is accompanied by a change in the arrangement of the minerals in the granite, producing a curving, schistose lamination.

Faulting in vein.

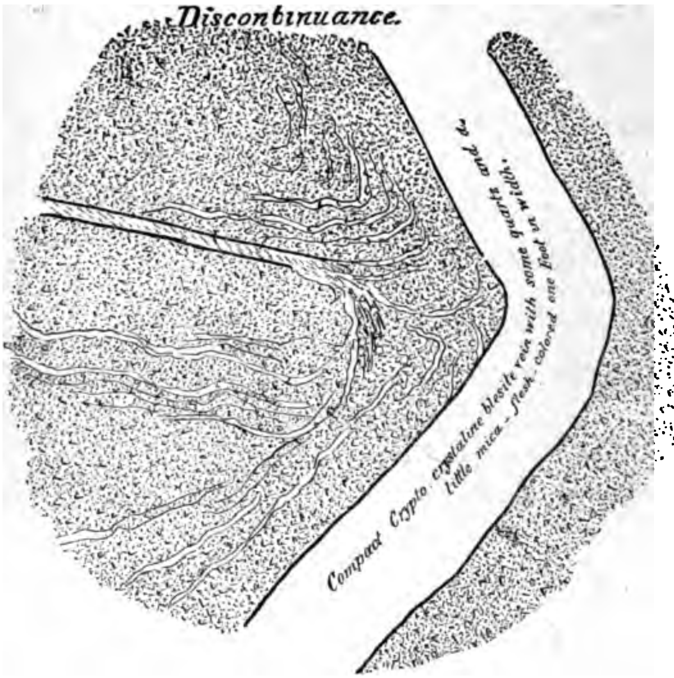


Sch Schistose granite.

In the second, the same vein is intercepted by a vein that has the outward aspect of orthoclase felsite, which seems to be of earlier date, inasmuch as the former is discontinued on reaching the latter. The discontinuance of the smaller vein seems to have been the cause of a certain ramifying schistose structure in the vicinity of the point of contact of the two veins. The felsite vein is one foot wide, and has a

flesh color, with probably considerable quartz crystallized with it. It also shows some mica. It faults another vein, and hence is of later date than it.

Discontinuance of vein in granite at Birch Coolie,



[For "Compact, Crypto-crystalline blesite," read Compact, crypto-crystalline felsite.]

Granite of the same composition and outward appearance as that below fort Ridgely outcrops on both sides of the Minnesota, at the mouth of Crow creek, sec. 35, T. 113, R. 35. It is here also superficially decomposed to the depth of several feet, forming a substance resembling kaolin, already mentioned as occurring at Birch Coolie. The usual points of exposure of this kaolin are in the banks of the little ravines that enter the Minnesota river. It is generally overlain by deposits of Cretaceous age, comprising clay, lignitic shale, sandstone or limestone. When the water carries this kaolin out on to the bottoms, and there spreads it over the surface, it becomes dry after the subsidence of the water, and then appears as a nearly white, exceedingly unctuous, glittering scum covering the ground. In this con-

dition it shows minute flakes and sheets, that appear like exfoliations of talc.

At the mouth of the Redwood river, on both sides of the Minnesota, granite outcrops give rise to many rocky hills and knolls. The Redwood river, for some distance before reaching the Minnesota bottoms, is channeled through granite rock. This, together with the excavated Cretaceous rocks overlying, and the drift deposits, gives the river a very deep gorge through which it flows at a rapid rate, sometimes plunging over precipitous or perpendicular rocky descents, presenting a series of waterfalls, rapids, and quiet, deep pools of confined water, which are rarely excelled for picturesque beauty. The river falls about 100 feet in half a mile.

The granite, through which the river is cañoned, is usually the typical ternary compound, but shows variations. It is sometimes slaty or schistose. Just below the flouring mill of Messrs. E. Birum and Brothers, the rock on the left side is cut by divisional planes into oblique cuboidal blocks, and is called, in the absence of better, a "building stone," from the ease with which it could be quarried. It is also schistose, made up largely of quartz grains which are coarse, mingled with fine, glittering flakes that may be talc or mica. The greenish color of the whole stone, on fresh fracture, gives the rock a talcose character, although there are also occasional black scales that are plainly micaceous. The most frequent divisional planes here, causing the slaty or schistose structure, run about NE. and SW., and slope at an angle of about 25 degrees below the horizon, toward the SE. This rock might be denominated a schistose and talcose quartzite.

At Redwood Falls the granite is overlain by the kaolin, which has been mentioned, presenting, in connection with this substance, a very interesting series of exposures, and suggesting very interesting questions both economical and scientific. About a mile below the village, on the left bank of the river, is a conspicuous white bluff,* composed of white kaolin clay. Near the top of this bluff, where the rains wash it, it is silvery white, and that color is spread over much of the lower portions, though the mass of the lower part is more stained with iron, having also a dull greenish tinge. The white glossy coating which appears like the result of washings by rains, is spread over the perpendicular sides. On breaking off this glossy coating, which is sometimes half an inch thick, the mass appears indistinctly

*This is probably that seen by Keating, and pronounced "white sandstone."

bedded horizontally, but contains hard lumps and irony deposits. Further down, the iron becomes more frequent, and gritty particles like quartz impede the edge of a knife. The bedding also is lost, and the closest inspection reveals no bedding. Yet there is, even then, a sloaping striation or arrangement of lines visible in some places on the fresh surface, that corresponds in direction with the direction of the principal cleavage plane of the talcose and quartzitic slate already described. In other places this arrangement is not seen, but the mass crumbles out in angular pieces which are superficially stained with iron. The profile of the bluff here presents a singular isolated knob or buttress that rises boldly from the very river, connected with the main bank by a narrow edge along which a man cannot walk with safety. On either side of this bold promontory are retreating angles in the bluff along which a descent can be made. A careful inspection of these ravines and of the adjoining bluffs affords indubitable proof that this material, white and impalpable as it is, results from a change in the underlying granitic rocks.

Just above this point, is another exposure. It here supplies what is locally known as the "paint rock," from an enterprise started several years ago in manufacture of mineral paint from this material. The decomposed granite here has very much the same appearance as the kaolin, already described, at Birch Coolie, but contains more quartz, and is more stained with iron. It has a greenish color, but within might be blue. It passes upward into the greenish, and then white, kaolin clay already described, but it stands out in a crumbling, rusty buttress, exposed to the weather, and has quartzitic veins and concretions, iron-coated, and often an impure iron ore in considerable quantities. It shows silvery or shining talcose flakes, the same as seen in the so-called building rock, a short distance below the mill of Birum brothers.

A short distance above this, nearly opposite Redwood Falls, is situated the rock which was quarried for the manufacture of paint. This has in every respect the same character and composition as that last described. It consists of a perpendicular bluff or point, standing out from a lower talus that rises about 75 feet above the river, to the hight of 75 feet more. On the top of this is the drift-clay hardpan, covered by four or five feet of sand and gravel, the whole bluff being about 150 feet above the river. This bold bluff, or promontory, stands between re-entrant angles, its face fall-

ing down sheer thirty or forty feet. There is here visible an irregular slaty or cleavage structure in the rock, that at a distance has the appearance of dip toward the S. E. 30°. This also contains quartz veins and deposits, accompanied by iron, in some places too abundantly to allow of being cut with a knife, though very much of it can be easily shaped with a knife. It shows "slickensides," or surfaces that seem to have been rubbed violently against each other, causing a scratched and smoothed appearance, even within the body of the bluff. These surfaces are concave or curving, like putty hardened after being pressed through a crevice.

Between Beaver Falls and Vicksburg the granitic rocks appear almost constantly in sight, rising in mounds or bald irregular slopes, along the river bottoms, reaching occasionally as high as the river bluffs. For some distance above Beaver Falls, a ridge of granitic rock, running along within the bluffs, divides the channel into two parts, both of which are sometimes occupied by water, no such rock, nor any other, being visible in the bluffs themselves.

At eight miles above Beaver Falls such rock occurs in great force in the river bottoms, giving the appearance of a village, at a distance, partly hid by the scant foliage. Here it occupies the whole valley, spurs running in either direction into the river bluffs.

At Vicksburg the river bottoms are crowded with granite mounds and hills, some of them holding large blocks of hornblende schist that lie *in situ*, the transition from granite to schist being very abrupt.

After passing Patterson's rapids (T. 114, 37), the next important granite exposure noted was at Minnesota Falls, situated in the north part of town 115, range 39, although small mounds of granite occur for three miles below. Here the river bottoms are occupied by a schistose granite, which splits up conveniently for foundation stone. The change in the character of the rock is evident in the generally turfed condition of the mounds. The rock is here intersected by veins of quartz and trap dykes, the latter being traceable across the valley for half a mile, running N. E. and S. W. This trap is heavy and dark green, with some shining faces on the hornblende, when freshly broken. In higher levels, and apparently overlying this bedded schistose granite, is a compact hard-weathering granite. It is of a gray or greenish-gray color much resembling the St. Cloud granite. The rock at Minnesota Falls differs very noticeably from any

observed in the river valley at lower points. It is bedded. and has a strong dip towards the S. E.

At a point, a short distance from the river, up a little ravine, that joins the Minnesota, opposite Austin and Worden's flouring mill at Minnesota Falls, the mineral already described as kaolin, or "paint rock," may be seen. This decomposing granite here holds quartz veins and deposits; which being coated with a lustrous black mineral, or holding it in sheltered angles or cavities, has attracted the attention of the settlers, who have regarded it as possibly an ore of silver or of copper. This mineral has a dark, brown powder. When in the form of films or sheets, or larger globules, it parts with a specular cleavage. In some places a considerable iron rust is seen in this quartz, and in others drusy or peppery crystals, as if of the same composition, are scattered over the surface, making it appear specked under the glass. These fine crystals make a lighter powder. Prof. Peckham pronounces this mineral to be hematite iron ore. It is specular.

The valley all the way between Minnesota Falls and Granite Falls is about two miles wide, and presents a singular billowy prospect, of granitic knobs, rising and falling on all sides, the river worming its way among them and having frequent rapids and water-falls, useful for mill privileges. At Granite Falls, as at Minnesota Falls, and all the way between, the rock in the valley is a schistose granite, almost a mica schist; but it varies to a hard gray granite that resembles that at St. Cloud both in color and composition. This, however, forms but a small part, the greater portion being schistose or laminated. It also varies to a red granite, i. e. one in which there are evident flesh-colored crystals of feldspar. These two variations do not seem to lie with any as certainable fixed relation of superposition to the schistose or bedded granite, but rise in knobs and irregular masses higher in the valley than that. They are not wooded, nor turfed, the schistose granite which more easily decomposes being generally turfed.

The most marked peculiarity of the granite at this place is its constant dip toward the S. E. This has been observed at several other points before reaching Granite Falls, but some uncertainty has generally existed in regard to the true character of the lamination seen, and it has not been spoken of as dip. Although the usual direction of inclination is toward the S. E., it varies, at Granite Falls, from S. E. to N. E. It amounts to 25 degrees, but sometimes reaches 40 degrees. At one place at Granite Falls the rock dips to

the north for some distance. The red and gray colors are variously mingled, without any apparent law of association or alternation. Although the patches of more massive and typical granite are suitable for a fine building material, they still show the same dip toward the S.E., and are distinctly bedded throughout. These hard knobs rise from ten to twenty feet above the general level of the other granite, and show various effects of running water.

The trap dykes, the direction of which is shown by the adjoined diagram, occur in the river bottoms, about a mile above Granite Falls.

Trap dykes at Granite Falls.

Bedded Granite. Dip irregular.

Trap dyke, 20 ft.

Granite, dip unascertainable, 54 ft.

N.E. — *S.W*

Greenstone trap dyke, 48 ft.

Granite, dip S.E.

There are sudden changes in the rock from real granite to hornblendic schist. These occur irregularly. A change like this gives rise to the waterfall near the flouring mill of Hon. Henry Hill, the fall being due to the greater resistance of the harder rock. The trap dykes above mentioned also cause rapids and waterfalls where they cross the river.

Between Granite Falls and Montevideo, at the mouth of the Chippewa river, the granite occasionally appears in the river bottoms. It was noticed at a point six miles below Montevideo, on the north side. The bedding, supposed to be due to original sedimentation, still dips to the east. It appears sometimes to stand nearly vertical. At this place occurs a belt or bed of hornblendic schist.

At two miles below Montevideo, is a conspicuous outcrop of compact hard granite, of a red color, lying mainly on the north side of the river, in the bottoms. This has the same dip, viz., 30 or 35 degrees to the southeast. The beds here regarded as representing dip, and at other points mentioned, should be further described. They are in thickness ½ to 2 or three inches, or they seem sometimes to be a foot or two. When weathered they appear thinner, and the granite then sometimes presents a slaty structure, the edges standing out sharply at the angle of dip. At Minnesota Falls

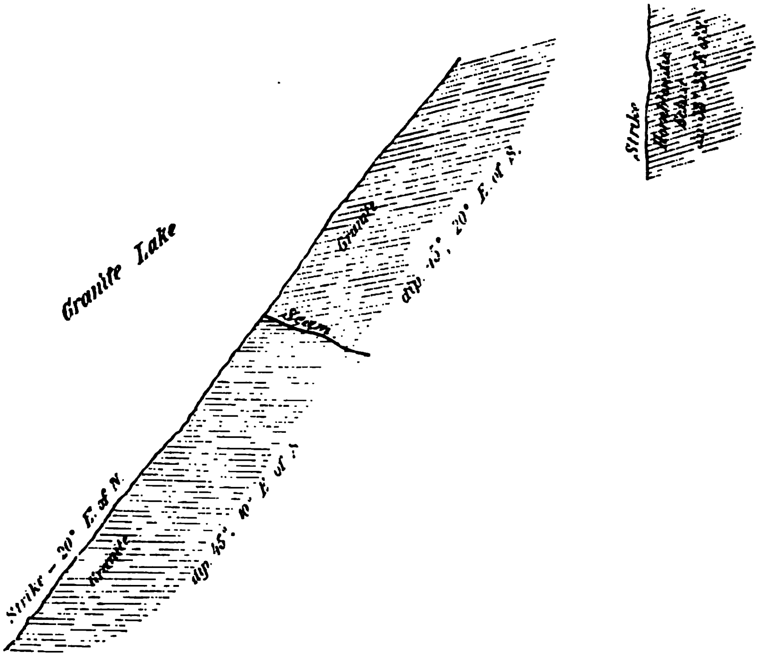
and from there to Granite Falls, these beds are so micaceous as to make what has been termed a schistose granite, the whole mass becoming easily disrupted by frost and water, and then turfed over. But at this place the beds are closely compacted, and the whole is almost massive. The thickness of the bedding can easily be seen, however, in the occasional thin sheets that part from the knobs, or in the striations that mark the faces of the water worn, bald knobs. Although these knobs rise at irregular intervals, and are variously situated with reference to each other, having sloughs between them, yet they are arranged somewhat in succession in one direction, making rows or almost somewhat continuous ridges, running parallel in the direction of the strike, N.E. and S.W., which of themselves indicate a system of bedding. On a weathered cross-section of the bedding, the marks of striation or sedimentation often show a wavy arrangement, or distorted parallelism, and sometimes they vanish and widen alternately. The dip measured in one place is here 58°, 10° east of south. At another point very near the last, it is 85° in the same direction. This granite has the color and apparent composition of that seen below fort Ridgely.

This granite shows occasionally a knob of hornblendic schist, rising among the granite mounds, having very much the form, dip and bedding of the granite.

There is also occasionally a mound or dyke of trap, or greenstone, split into shapeless blocks under the weather, the planes of division running in various directions. These have no bedding, nor dip, but are very heavy, and uniformly of a dark green color. They do not disturb the uniformity of dip in the granite.

The following diagram will exhibit some of the features of the granite as exposed two miles below Montevideo:

Granite two miles below Montevideo, Chippewa Co.



The change in the direction of dip in the granite here sketched is rather less sudden than here represented. The seam, or joint, marking the point of contact of the beds dipping in different directions, is very much covered with turf, and the manner of union cannot be ascertained definitely, but on the face of the bluff (strike) there is no apparent disturbance or irregularity.

A belt or wedge-shaped, lenticular mass of hornblendic schist occurs in the granite here described, on the land of Mrs. E. A. Hull, having a more easterly dip, and running N. W. and S. E. It is 20 rods long, and from 20 ft. to 6 rods wide. Its dimensions and form cannot be fully and exactly seen. It appears in low knobs much like the granite, and the intervals of non-exposure are grassy.

Mr. L. R. Moyer, county surveyor of Chippewa county, reports granite on the prairie, three miles east of Montevideo, and in the Minnesota bottoms, a mile above Montevideo.

Near the lower end of Lac-qui-parle lake, granite appears on both sides of the lake. It is usually inaccessible from

the prevalence of water; but in the dry months of the year it can be reached on the north side without any trouble, except from tall grass and bushes. There are three or four small bare spots on the south shore that can be seen, and three or four others that rise up in the midst of the lake. Two of these spots of bare rock also occur on the north side, near the foot of the lake. This rock, so far as can be seen on the north side, shows very much the same composition as further down the river. It contains quartz, mica and flesh-colored feldspar, with patches and veins of quartz, some of which are mingled with porphyritic feldspar. The exposed surfaces are annually submerged, or nearly so, and do not exhibit very plainly such markings as indicate sedimentation or dip. There seems to be an indistinct arrangement of the mica scales, so as to give the rock a schistose structure, but this, although generally running N. E. and S. W., does not have that direction invariably, and does not at all represent the lamination or bedding seen below and already described. In only one small area can there be seen what looks like the same bedding, and there it is but six inches in thickness, the beds being one or two or three inches, with a dip of 75° toward the S. E. Jointing planes divide the whole mass into blocks and rhombs, four or five or six feet in thickness. There is considerable low land about the lake, much of which is flooded at the wet season of the year, but it is stony and bushy, and has the appearance of rock in a great many places near the surface. Such appearances are seen the whole length of the lake, and especially on the north side. About three miles above the foot of the lake, rock can be seen on the south side at two points, rising plainly above the general level of the bottoms, and ascending in the slope from the prairie. Such exposures continue to near the head of the little lake in T. 120, R. 44, where granite appears in several places on the south side of the river.

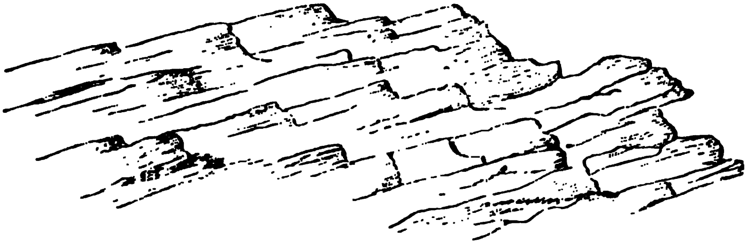
Further up the river, near where it enters T. 120, R. 44, may be seen a large exposure of coarse granite. The crystals of feldspar are large and flesh-colored, or red. Yet the granite also varies to a lighter color, in which the feldspar is nearly white. It shows, in the latter case, a perpendicular jointing, the planes being one or two or three inches apart. The whole exposure consists of bare, massive, rounded knobs, cut into angular rhomboidal blocks, by jointing planes, but in no place showing the dip seen lower down the Minnesota river.

Granite also outcrops about three-quarters of a mile above Mr. F. Frankhouse's, on the south side of the river, two miles above the last.

Red granite also appears about a mile further up, in the river bottoms, near Mr. W. Movius' house, presenting an irregular exterior, showing no dip, although there are here also conspicuous jointing planes. This is about three-fourths of a mile above the mouth of the Yellow Banks creek. Opposite Mr. Movius', on the south side, in the bottoms, may be seen another similar granite mound.

At three miles below the foot of Big Stone lake, there is a tumultuous outcrop of red granite, extending to the lake, on both sides of the river. This shows planed and striated surfaces on a grand scale. These marks have a N.W. and S.E. direction (corrected for variation), or that, in general, of the Minnesota valley. The whole rock, including the upper surfaces and the sides of the mounds, is planed off. The best exhibition of these markings is seen on the northwestern slopes, in which direction there is a system of jointing planes, dividing the granite into blocks that have at first sight a strong semblance of dip, the masses breaking off more nearly at right angles on the southeast side. This is a coarse, red granite, with large crystals of feldspar. The following diagram illustrates the effect of the jointing in the rock, acted upon by glacial forces from the northwest.

Jointing and glaciation at Big Stone lake.



Above the foot of Big Stone lake there is no known outcrop of granite throughout its extent. Cretaceous rocks constitute the only outcrops. These are seen sometimes in the little creeks that enter it, and are outlined as terraces on its banks.

The examiners of the land of the Winona and St. Peter R. R. report granite *in situ*, on the prairie, T. 113, R. 43, sec. 17, and T. 113, R. 39, sec. 29.

Further examination of the granitic belt was made at Sauk Rapids and St. Cloud, for the purpose of comparison with the granites of the Minnesota valley, and with a view to some parallelization; but as that region will undergo a more detailed survey, and no results were obtained bearing on the subject of the relative age of the rocks at that place and the granite of the Minnesota valley, those observations are reserved for future comparisons.

(j) THE CRETACEOUS.

In the progress of the season's work, the first point at which these rocks were seen was in Dakota county. At Empire City, where the highway crosses the Vermilion, sec. 24, T. 114, R. 19, the river is handsomely terraced. The valley between the lowest benches that rise on each side is from one to two miles wide. The first terrace is very conspicuous in the treeless landscape, and consists superficially of coarse drift. Its crest is gently rounded off. It is occupied with fine farms. The same is true of the land lying along its base, which might be called the flood plain of the river. Yet it is probable the river never floods the greater part of it. Some of this plain is wet and grassy, making fine meadow land, and other parts of it are plowed for wheat. The first terrace seems sometimes broken, about midway, into two terraces, the constancy of which could not, however, be discovered. It is subject to numerous re-entrant bends and other sinuosities, the points intervening being stony and only fit for pasturage. The pebbles are generally quartzitic, and lie very thick on the surface. They are rounded as by water. The hight of this terrace above the river, measured by Mr. Furber by Locke's level, was found to be 81 ft. 3 in. Above this terrace there is a further ascent to the level of the general prairie. What part the St. Peter sandstone, which forms *lone rock* a short distance north, and shows an outcrop in the valley a short distance up the river, plays in the formation of this terraced slope to the Vermilion, cannot be certainly ascertained, but it probably is very small. The Cretaceous clays and shales, with their associated loose sandstones, however, are perfectly adapted to the formation of terraces along streams, as has been, and will be further mentioned in describing the Minnesota valley, and they are believed to be the sole cause of these terraces. If the reader wishes to investigate this subject further, he is referred to those chapters and para-

graphs that describe the terraces of the Minnesota, and discuss the drift and its phenomena. This assignment of these terraces to the agency of the stratified deposits of the Cretaceous does not rest on bare opinion. The Cretaceous clay was seen in outcrop near the bridge over the Vermilion near Empire City. The destructible nature of these beds causes them to be covered by loose materials, which, after the lapse of time, spread over the entire surface, and superficially appear to compose the whole substructure. The beds themselves are thus only outlined in the form of terraces.

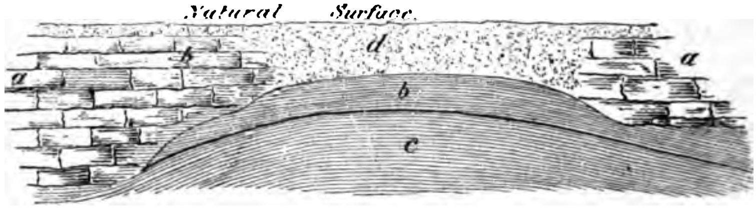
In ascending the Minnesota valley the first point at which the Cretaceous was indentified, so far as it can be without the aid of fossils, is at the Asylum farm, near St. Peter, in Nicollet county. It lies here in the water-worn openings of the Shakopee limestone. It is a white, or greenish-white deposit, holding much sand. It has a great many flinty fragments, and some siliceous limestone lumps. The latter are rounded, but the former are angular. The lumps are porous, crystalline, hard, and gray or white. No fossils can be seen, and no stratification. It seems rather to have been *jammed* into the openings in the Shakopee stone. A similar exposure, presenting the same characters, occurs across the river from St. Peter, and about a mile toward Kasota, in a bluff by the side of the road.

A heavy bed of white sand, which has been described as probably belonging to the St. Peter sandstone (p. 134), occurs on the Blue Earth and its tributaries. It is associated with an impure iron ore, and with light green shale, but its exact relation to them has not been ascertained. It may belong to the Cretaceous.

At Mankato, in Blue Earth county, a series of very interesting observations was made on the Cretaceous, throwing some light on the history of that period of submergence which brought the most of Minnesota below the ocean. Where the road to South Bend crosses the Blue Earth, on the east side of the bridge, is a cut in greenish clay, by the side of the road. This deposit of clay lies in a nook alongside the bluff of Lower Silurian, and doubtless was protected from destruction in the glacial period by that bluff. It is covered with drift, and at one place occupies a cleft in the Silurian rock, running nearly to the surface of the ground at the top of the bluff. Its position here, and as represented in the following sketch, is very deceptive. It appears very much as if in place in the Shakopee stone, but the beds of

that stone hold as low a place, horizontally, a little further to the left, as this clay. The bluff of Lower Silurian can be seen to disappear behind the clay, in some places the clay being removed so as to show the bluff at lower points than at others. There is every indication that this deposit is of small extent.

The Cretaceous at Mankato.



Explanation.

a. Shakopee Limestone.
b. Bedded, greenish clay, weathering white, but little sandy.
c. Sandy, bedded greenish clay.
d. Drift, mostly coarse fragments of Shakopee Limestone.

Passing along the right bank of the Blue Earth river from the highway to the railroad bridge, we come to a cut in the Shakopee stone. This is in the same horizon as that just described, and shows more fully the manner of superposition of the Cretaceous on the Silurian rocks. This cut is perhaps 70 feet above the river, the bank of which is composed entirely of rock, the lower portion of which is the Jordan Sandstone, and the upper, the Shakopee limestone, the latter comprising about 20 feet. In general this railroad cut shows a mixture of Cretaceous clay with the Lower Silurian, the top of the whole being thinly and irregularly covered over and chinked up with coarse drift. The Lower Silurian is more or less broken and tilted, at least the bedding seems to have been cut out into huge blocks by divisional planes, which, either by weathering or water-wearing, were widened, the blocks themselves being subsequently thrown to some extent from their horizontality, tipping in all directions. The opened cracks and seams were then filled with the Cretaceous clay, which is deposited between these loosened masses, and sometimes even to the depth of twenty feet below the general surface of the top of the rock. The clay sometimes occupies nooks and rounded angles, sometimes sheltered *below* heavy masses of the Silurian beds.

The clay is uniformly bedded, about horizontally, with some slope in accordance with the surface on which the sedimentation took place. But the most interesting and important feature is *the condition of these old Silurian surfaces.* They are rounded by the action of water, evidently waves. The cavities and porous spots are more deeply eroded, making little pits on the face of the rock; or along the lines of section of the sedimentation planes with the eroded surface, there are furrows due to the greater effect of water. The rounded surface of these huge masses of Lower Silurian is coated with a thickness of about a half inch, or an inch and a half, of iron ore, which scales off easily, and is easily broken by the hammer. While this scale of iron ore is thicker near the top and on the upper surfaces of the blocks, yet it runs down between the Cretaceous clay and the body of the rock, so as to prove its date older than the clay. The conclusions that must be drawn from this observation are about as follows:

1st. The Silurian rocks were long weathered, and washed clean, even water-worn and rounded, at this place, when they went below the Cretaceous ocean. Nothing intervenes between their iron stained surfaces and the clay.

2nd. This point seems to have been on or near the ancient shore line, where the violence of the waves was great. These rounded knobs could not have received their coating of iron if constantly submerged. The iron indicates the action of atmospheric gases on iron held in solution in water, as a bog ore formation.

3rd. The Cretaceous clay here, whatever be its place in the Cretaceous age, was deposited in a quiet ocean.

4th. This bluff, facing to the south, or south-east, like that at Mankato, indicates the approach of the Cretaceous ocean from that direction, though this may have been only a reef, or an island, just before the further submergence.

5th. There may have been, and was probably, a further deposition of clay of the Cretaceous age which was destroyed and transported by the drift period, at this place.

6th. The drift succeeded, and was not violent enough in its forces to disturb these tilted and waterworn masses of Lower Silurian limestone, so but that their old surfaces abut still unconformably against the Cretaceous clay.

7th. The Cretaceous sea must have advanced slowly over the Silurian rocks. These washed surfaces could not have been produced when the sea was retiring, else the Cretaceous sea would have washed out the clay. Further the clay lies directly in contact with these surfaces.

8th. The Cretaceous sea must have gone farther north and east so as to deeply submerge these disturbed masses. in order to have deposited such fine sediment in their crevices.

9th. While the washed surfaces indicate a shore line. or a reef, the clay proves deep submergence.

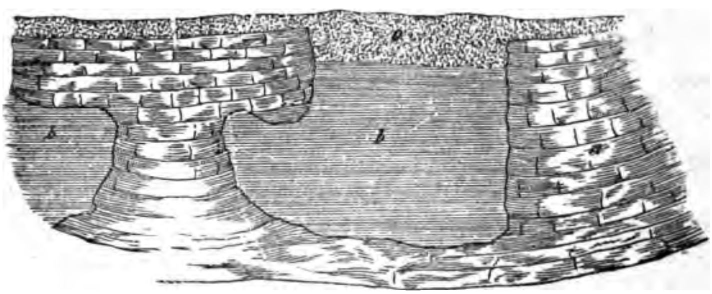
10th. The Cretaceous sea must have retired rapidly, so as to give no opportunity to wash out the clay.

11th. These washed surfaces must have been produced as the sea was advancing.

12th. While it is certain that the Cretaceous sea advanced slowly on the land, it is not certain that it retired rapidly. The clay existing there may have been protected from the retiring shore waves by superimposed beds hundreds of feet thick -such higher beds having been subsequently removed by the drift forces; but it is likely that drift forces that were able to destroy so much Cretaceous, would also so have disturbed the Silurian masses as to leave no trace of the clay, or even to have transported away the Silurian masses themselves. Hence it is probable that there was but little Cretaceous deposited over the remaining clay, and that the sea retired rapidly.

The adjoining sketches will give a better idea of the position of the Cretaceous, with respect to the Silurian.

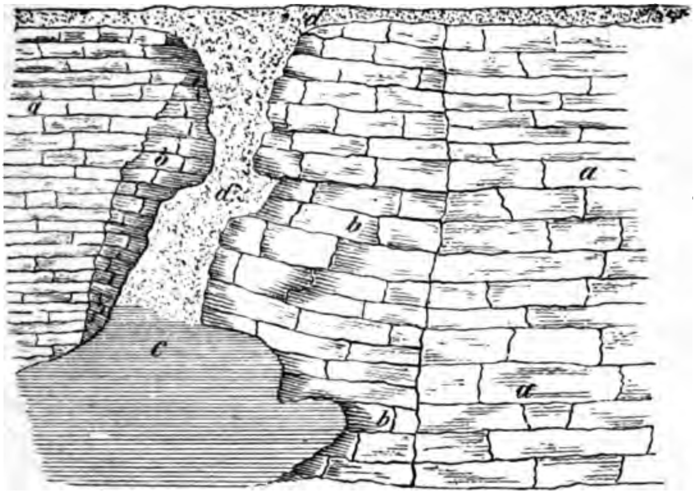
The Cretaceous on the Lower Silurian.



Explanation.

a. Weathered surface of Silurian.
b. Cretaceous clay.
c. Coarse drift

The Cretaceous on the Silurian.



Explanation.

a. Silurian rock, cut by the grading of R. R.
b. Weathered surface of Silurian rock.
c. Cretaceous clay, greenish blue, bedded.
d. Coarse drift.

On sec. 25, T. 108, R. 29, (as nearly as can be made out), is an exposure of Cretaceous clay. The bank of the flood plain of the river is made up, almost everywhere, of sandy, more or less stratified, alluvium. But here, although having about the same hight, it is made up almost entirely of a mass of large, water-washed fragments of conglomeritic sandstone, which lie in confusion, some having fallen down into the water. They are underlain by a fine blue clay, without gravel or pebbles, belonging to the Cretaceous. Hence the sandstone or conglomerate pieces are not *in situ*, but pertain to the drift. Sometimes a layer of drift-pebbles and cobble-stones, about three inches thick, separates them from the clay. These large masses are 8 or 12 feet long, and 5 or 6 feet thick, and are scattered in talus over the Cretaceous clay, even into the river.

Dr. B. F. Shumard, in his report on the Minnesota valley, has mentioned an outcrop of *formation 1 capped with about 25 feet of gray, concretionary limestone*, about two miles below the mouth of the Waraju, and describes it as having disseminated crystals of calcareous spar. His analysis shows it to hold 90 per cent. of carbonate of lime. A

very long search was made for this exposure in the season of 1873. It could not be found—that is to say, nothing could be found pertaining to the Silurian rocks. A sandstone was seen in outcrop on sec. 16, T. 109, R. 29, on the north side of the river, in Nicollet county, quarried a little by Wm. Fritz, which proved to pertain to the Cretaceous, holding dicotyledonous leaves and branches. It consists of alternating layers of friable sand with angular shapes, but little rounded by attrition, and hard, cemented gray sandstone, which is sometimes coarse enough to be styled conglomeritic. The section here is as follows, the upper members being somewhat displaced by the washing out of the friable layers.

Section in Cretaceous sandstone. Land of Wm. Fritz, sec. 16, T. 109, R. 29, Nicollet Co.

No. 1.	Hard, gray sandstone, rusted in the weather, and checking into beds of about four inches,—sometimes one or two inches	18 in.
No. 2.	Friable white sand	10 in.
No. 3.	One course of gray sandstone, of variable thickness	1-3 ft.
No. 4.	White sand	6 in.
No. 5.	Gray sandstone, quarrying out in layers 6-10 inches thick, but in the quarry appearing massive; very hard, the cement appearing to be silica. It contains fragments of wood, charcoal and angiospermous leaves. Its under surface is undulatory, its thickness varying from	3-6 ft.
No. 6.	White, friable sand, seen	3 ft.

This whole quarry lies perhaps 35 or 40 feet above the river, and 40 or 50 rods from it. The persistency of this group of layers is evidenced along here by their forming a little terrace above the bottoms, which rises about 25 feet, and is visible for more than a mile. Pieces of this stone had been seen at lower points on the river, said to have been taken from the beds *in situ*, but it had been impossible to find those beds. One such place was at Mr. E. Rowe's, on sec. 23, T. 109, R. 29, on the south side of the river.

Four miles below New Ulm, on the south side of the river, is a bluff made up of Cretaceous, on the land of John Gruebel, as follows:

Section on sec. 2, T. 109, R. 30.

No. 1.	Black alluvium	2 ft.
	Passing below into	
No. 2.	Clayey alluvium, of a light-brown color	4½ ft.

No. 3.	Red clay, containing some sandstone in masses: stratified	2½ ft.
No. 4.	Belt of greenish, sandy clay .... Passing into—	1 ft.
No. 5.	Sandy clay, of a light umber color	1½ ft.
No. 6.	Bedded sandy clay, of an earth color, (same as No. 2)....	2 ft.
No. 7.	Greenish sand, the color coming from the mixture of green shale with the sand, the grains of sand being white quartz..........................	2 in.
No. 8.	White sandstone, in one bed, or weathering into beds of two inches....................................	1 ft.
No. 9.	Green bedded shale, or clay, with some fine sand grains, and some laminations or thick beds that are all white sand, but generally maintaining a green color, seen...	18 ft.
No. 10.	Slope and talus..	10 ft.

The bedding seen in the foregoing section is horizontal. and shows no fossils. Although there is no opportunity at this place to determine whether this series of shales lies above or below the sandstone at Fritz's, by an observation made in the bank of the road at the crossing of the Waraju, it is believed to overlie that sandstone, but to underlie a series of calcareous beds that appear in the right bank of the river, about a mile below the mouth of the Waraju. The colors near the top of the foregoing section exchange places a little, in following the bluff along, drift boulders and gravel occupying the place of clay, in No. 3. In some places the red, irony stain passes down lower. It is likely that the red, brown and ochery colors are due to ferriferous waters, since the deposit of the Cretaceous, and to oxygen in the air. Hence it is not certain that the drift extends through the whole of No. 3, although drift boulders are mixed with it, or replace it, in some places. When evenly bedded and free from boulders, it undoubtedly belongs to the Cretaceous, the drift stopping with No. 2. When it is replaced by boulders, the Cretaceous is only so much the more worn away, the color pervading them, or passing down to lower beds.

From the mouth of the Waraju going down the right bank of the Minnesota, a regular terrace is seen to rise several feet above the flood plain. About a mile down, this terrace shows its origin and composition, in the banks of a ravine which cuts it. (See map of this locality, page 157.) Before reaching that point, however, an outcrop of "gray concretionary limestone" is seen on the top of the terrace plateau. This limestone here is overlain by a couple of feet of water-washed limestone, gravel and cobble-stones, mixed toward the top with the usual black alluvium. The appearance of the quarried stone is like *drift* pieces, and the bed from which it is taken is intersected variously with

divisional planes, cutting the mass into irregular fragments, which, on being taken out, appear weathered. Yet there are crystal-lined cavities, some parts of it being mostly made up of calc-spar. Since the formation of the crystals, calcareous water has again deposited lime on the edges of the crystals, which, having first been of the thin (axe-shaped) variety, have now the appearance of separate but crowded cock's combs, the little, beaded accretions of lime being arranged on their edges. There is also a considerable quantity of uncrystallized lime on other surfaces. The interior of the stone is of a light gray or drab color, and when compact and free from crystals, is very fine grained. It is said to make a white, strong quicklime, of which there can be no doubt. This limestone outcrop, which shows only about 16 inches, is within a mile of the red quartzite outcrop near New Ulm, the bare bald surfaces of which are visible, from this point, on the other side of the Minnesota.

A little below the last described exposure, is Mr. Wm. Winkelmann's lime-kiln and quarry. The stone here burned is in the same horizon, and comes from the banks of a ravine that here enters the Minnesota. The limestone is much mixed, confusedly, with shale, but the following general section can be made out, in which no fossils were seen:

Section at Wm. Winkelmann's, near New Ulm, in Brown county.

No. 1.	Alluvium and boulders	2 ft.
No. 2.	Green shale, interstratified with belts and irregular nodules or masses of gray limestone	15 ft.
No. 3.	Green shale	1 ft.
No. 4.	White sand, varying to green shale	1½ ft
No. 5.	Green clay	2 ft.
No. 6.	Calcareous shale, or marl, with some argillaceous matter	5 ft
No. 7.	Green shale, or clay, with blotches of red, seen	1 ft.
	Total	27½ ft.

The same kind of greenish marl is exposed up the Waraju, the immediate bluffs being somewhat wrought in it, to a point just back of New Ulm, where the bank is opened by Mr. Winkelmann for laying pipes to supply his machinery and brick-yard. The trench which he has dug passes through it just before reaching the bank of the Waraju river. The flat on which New Ulm stands seems to be made up by a terrace wrought in the Cretaceous. The surface of this flat is strewn with boulders.

Another creek joins the Minnesota nearly opposite the mouth of the Waraju, and also afords such exposures of the Cretaceous limestone as to invite the construction of lime-kilns. The sections here seen are not so favorable as that of Mr. Winkelmann, and contain more shale, some of which shows also a red color. In the shale are crystals of selenite; exposed ten feet. The kilns at this place are owned by John Heiman and Francis Baasen.

On the Waraju, about three miles from New Ulm, Mr. Christan Dauffenbach has established a manufactory of fire-brick. He obtains the material from the left bank of the river, where the Cretaceous affords the following section:

Section in Cretaceous on the Waraju river.

No. 1.	Hardpan drift, made up of clay and stones, seen about..	30 ft.
No. 2.	White sand, the age of which is uncertain, containing irony concretions and deposits. It is somewhat indistinctly stratified obliquely, like drift sand, and has some coarse grains. Its position in reference to the overlying hardpan drift, together with its thickness and purely white color, indicates its age to be Cretaceous....	100 ft.
No. 3.	Blue clay, containing some siliceo-calcareous, irony lumps; said by Mr. Dauffenbach to hold some coal, mixed with No. 4 for making fire-brick....................	4 ft.
No. 4.	Sandy marl, probably largely aluminous, pronounced a silicate of magnesia by the chemist of the agricultural department at Washington. It is white, and when long submerged, soft and fluid-like, but when dry has to be quarried by blasting. This, mixed at the rate of two-thirds, with one-third of No. 3, makes a fine white, fire-brick—seen.....................	12 ft.
	Total hight of bluff................................	146 ft.

The above section varies in short intervals. In connection with others seen at New Ulm, it shows how careful geologists must be in attributing to drift all that is found before striking the indurated rock.

Under the guidance of Mr. Dauffenbach, about half a mile further up the river, a sandstone outcrop was encountered. It rises in a bluff immediately from the water, on the opposite side of the river. In this sandstone, which here appears firm and massive, and which is probably the equivalent of No. 2, of the foregoing section, are many irony mud balls, or concretions, having a fancied resemblance to plums or bananas. They vary in shape and size. They have been gathered as fossil "fruits," and sent east as rare curiosities.

The general section of the Cretaceous at New Ulm is as follows:

No 1.	Drift, gravel and boulders, with a surface-loam in some places, or largely made up of sand	10 to 20 ft.
No. 2.	Fine clay, blue, bedded, weathering white, used for pottery or brick	4 to 10 ft.
No. 3.	Sand or fine gravel, not cemented, readily crumbling, containing magnesian balls, or rounded lumps made up of a fine white powder—seen	20 to 30 ft.

The conspicuous Cretaceous terrace that occurs along the Minnesota at New Ulm, is due to this fine crumbling sand, overlain by a more tenaceous clay or shale. The varying composition of the Cretaceous makes it difficult to establish the horizontality of different outcrops, but there cannot be much doubt that No. 3 above is the equivalent of No. 2 of the section on the Waraju.

In the southwestern part of T. 110, R. 31, is another important exposure of the Cretaceous. It is in the banks of the Waraju, and consists of blue clay, and is used by the potters both at Mankato and New Ulm. That which is most highly esteemed is taken from the right bank about 40 feet above the river. It contains no gravel, nor any perceptible grit. It is owned by Silas Barnard.

A trial was made by Mr. H. B. Kaufer, potter at Mankato, of a clay outcrop on the other side of the river, about a quarter of a mile further up. Although this is about the same altitude above the river, and has outwardly the same general color and character, it is said to have proved unfit for potter's use, owing to the occurrence of small, black, hard, roughened pebbles, that can be broken only with great pressure, called "sulphur balls." These small specks weather black, and are doubtless composed of crystalline sulphuret of iron.

At Sleepy Eye, T. 110, R. 32, the Winona and St. Peter R. R. Company are sinking a well for artesian water. At the depth of 143 feet the drill had passed through the following section:

Black loam	5 or 6 feet.
Gravelly, brown clay	20 feet.
Gravelly, blue clay	115 feet.
Soft, pulpy, blue clay, that has [illegible] the tubing of the well	3 feet.
Total depth	143 feet.

In sinking a former drill, a pocket of coal was met in the gravelly, blue clay, at the depth of 75 or 80 feet.

The Cretaceous again occurs in the banks of Little Rock creek, near fort Ridgely, and was at one time explored there for coal.

At a point two miles below the Lower Sioux Agency, sec. 10, T. 112, R. 34, on the north side of the Minnesota, a small creek joins the river. Up this creek, about three-quarters of a mile from the river bluffs, the Cretaceous appears in its banks. A concretionary marl, or apparently limy earth, of a white color, crumbles out under the projecting turf. It appears in fragments of an inch or two, or sometimes larger, with angular outline. The surfaces of these pieces show a great number of round or oval spots, or rings, which seem to be formed by the sections of concretions inclosed in the mass. It is rather hard when dry, and nearly white. It is associated with a blue clay, the relations of which cannot here be made out.

At a point a little further up this creek appears a heavy deposit of concretionary, rusty marl, or ferro-calcareous substance, the exact composition and proper name of which it is impossible to give, before it has been chemically examined. It is in heavy beds, that fall off in large fragments, like rock. The first impression is that the bluff is composed of ferruginous conglomerate, but there is not a foreign pebble in it. Every little round mass has a thin shell which is easily broken, revealing either a cavity or a loose, dry earth. These concretions are generally not more than 1-4 or 1-2 inch in diameter; seen 18 feet. Under this is the light, concretionary clay or marl already described.

At the Lower Agency an exposure of the Cretaceous occurs in the road, seen in descending to the ferry. It consists of a sandy marl. Beds horizontal, or nearly so.

In the banks of Crow creek, which enters the Minnesota 3½ miles below Redwood Falls, the Cretaceous beds are carbonaceous, and have been considerably explored for coal, on the land of George Johnson. In 1871, Wm. H Grant, of St. Paul, entered upon a systematic examination of these layers, drifting into the side of the ravine 200 or 250 feet. This work is said to have cost about $2,000. A similar "coal mine" was opened in the banks of the Redwood, near Redwood Falls, where $5,000 are said to have been expended in a like fruitless attempt. This coal is from one of those layers in the Cretaceous that are usually known as lignites. It is earthy, passing sometimes into a good cannel coal, or into a bituminous clay. The compact cannel coal is in detached lumps, and occurs throughout a band of about

four feet in thickness. This lignitic band was followed in drifting into the bank of Crow creek, and was found to divide by interstratification with black clay, showing some leafy impressions and pieces of charcoal.

The "coal" here is said to overlie a bed of lumpy, concretionary marl, similar to that described at two miles below the Lower Agency, or two and a half miles below Birch Coolie. In some of the concretions are small shining balls of pyrites, which the workmen treasured up as gold. Over the "coal" is a blue clay, requiring a timbered roof in the tunnel. This clay is likewise Cretaceous. The underlying lumpy or concretionary white marl becomes siliceous, or even arenaceous, the concretions appearing more like chert. Some of it is also pebbly, showing the action of water currents.

The same lignitic coal occurs near Mr. Johnson's on the land of Hugh Curry, Wm. H. Cornell, E. O. King and Mr. Riker's, in the little ravines that enter the Minnesota, the exposures being kept fresh by the freshet waters. More or less exploring and drilling, besides that done by Mr. Grant, has been engaged in, in this vicinity, but never with any better success.

Near Redwood Falls, on land of Mr. Birney Flynn, is another outcrop of carbonaceous deposit in the Cretaceous. This is seen in the left bank of the Redwood river. It is in the form of a black bedded clay or shale, five or six feet thick, more or less mingled with charcoal and ashes, the whole passing below into charcoal fragments mixed with the same ash-like substance. In the latter are sometimes large pieces of fine, black, very compact coal, the same as that already spoken of at Crow creek, as cannel coal. These masses show sometimes what appears to the eye to be fine woody fiber, as if they, too, were simply charred wood. Further examination will be needed to determine their origin and nature. They constitute the only really valuable portions of the bed, the light charcoal which everywhere shows the distinct woody fiber, being generally mixed with the light ashy substance, and in a state of fine subdivision.

A short distance above Mr. Flynn's land is that of George Houghton, where the Redwood Falls coal mine was opened.

This mine consists of a drift into the bluff, forty feet, following a lignite, or charcoal bed in the Cretaceous. The bed here is seven feet think, the greater part of it being made of black, bedded shale or clay, though Mr. Flynn is authority for the statement that it showed a great deal

more of the real charcoal than any other point discovered. Some fragments that lay near the opening contained about nine parts of light charcoal to one of ash, the whole very slightly cemented, and so frail as to hardly endure transportation. In this drift were also numerous pieces of what is described by the owners both here and at Crow creek, as "stone coal." It is the same as that mentioned as probably a cannel coal, occurring at Crow creek. It is these harder lumps that are found scattered in the drift throughout the southwestern part of the state, so often mentioned in the newspapers.

Up a little creek that comes into the Yellow Medicine river from the south, near the village, is an exposure of fine stratified blue clay that weathers to a yellowish color. It has a thickness of at least ten or fifteen feet.

At a point six miles below Montevideo, on the north side of the Minnesota, there is a terrace within the main river bluffs, extending along the river for three miles at least, on which there is a wide plateau. This terrace rises 45 or 50 feet above the water, the flood plain being about 12 feet. On examining for the cause of this terrace, the only indurated rock found was in a little point that juts out toward the river about on a level with the top of the terrace: and that consists of granite, overstrewn with boulders. The terrace, however, is probably not due to underlying granite, for the surface of granite would not be so nearly level as to give the uniformity and regularity of outline here seen. It is more likely that Cretaceous rock, of a fragile and crumbling character, is concerned in giving form to this terrace, as has been seen in a number of other cases.

A mile further up the river, this bench shows a fresh section down to the water level. In general, the whole consists of fine sand, in which swallows burrow and breed. It stands, however, in nearly perpendicular walls, something like the "bluff." Yet it is not the *bluff*, because it is too fine, has no shells nor pebbles, and is stratified. It also becomes a bright blue color near the water level, and shows a sticky, clayey consistency, indicating a good material for brick. It cannot be of the same date and origin as the *bluff*, since it is an isolated instance of the occurrence of such beds along the Minnesota valley. It has very much the character of a late alluvial deposit, but rises too high to be of the same date as the flood-plain of the river. It is throughout mainly sand. The sedimentation is not always horizontal, if the individual layers be regarded separately, but it is if

taken collectively. There is a wave-like arrangement or anastomosing of layers; some are quite oblique and cross-bedded. In some parts of the upper 25 feet there is a rustiness, confined to certain thin beds, which makes them adhere in masses after falling out of the bluff, and at a distance have something of the appearance of sandrock. These, however, crush down at once under the hammer, or even in the fingers. While this deposit has very much the aspect of fine drift, its occurrence here in the form of a wide, continuous plateau, rising nearly fifty feet above the water, makes it very probable that it belongs to the Cretaceous, although it differs from any rock of that age before seen.

About half a mile, a little west of south from the stage station at the head of Big Stone lake, in Dacotah, an exposure of Cretaceous occurs in the right bank of the upper Minnesota. It shows superficially only a weathered, sliding talus of shale, which is black and somewhat slaty, but which on digging becomes moister and soft and somewhat flexible, yet parting into small chips. Over the surface of the ground, where this shale outcrops, the turf is prevented from growing, and two conspicuous objects, weathered out from the shale, are seen. 1st. Little angular crystals of pure gypsum, the largest seen weighing not over half a pound. 2d. Little angular bits of yellowish red ochre, that are hard and thin, but can be cut with a knife. There is also an occasional piece of brecciated, clayey, or at least aluminous rock, the cracks and surfaces of which are filled and coated with crystals of calc-spar. When broken by the hammer, these part along the numerous planes that on either side are lined by this calc-spar, and each fragment is entire, appearing itself a mass of calcite. It is only by several attempts that a view of the interior, on which these coatings are formed, can be obtained. The thickness of this shale bed cannot be ascertained. The angular bits of ochre are most numerous near the top, where the drift supervenes, but the gypsum crystals are scattered over the whole outcrop. The indications are that the gypsum and ochre are embraced within the shale, and become superficial by weathering. The whole may be twenty five feet thick.

This shale bed is the cause of a terrace in the descent from the high prairie, and of numerous springs that issue below the drift, about sixty feet below the prairie level. These springs excavate narrow ravines and "gulches" in the shale, the whole being smoothly turfed over, except at

the point above described. These alternating gulches, and the intervening short pieces of the remaining terrace, make the bluff in general appear hilly, in its ascent from the bottom-land. These ravines, in the wet season of the year, are very soft, and since they appear practicable for a horse, are the cause of many misfortunes to the traveler. Many such treacherous, springy places are described as occurring along the shores of lake Travers, at some elevation above the waters of the lake. The same rolling ascent from the bottom land to the high prairie can be seen also at the head of Big Stone lake, on the Minnesota side, and it is there doubtless, due to the same cause.

General section of the Cretaceous in southwestern Minnesota.

The limited observations that have been made on the Cretaceous in Minnesota, will not warrant a conclusion on the alternation of parts described in the foregoing account of the Minnesota valley. The beds are nearly horizontal everywhere seen, a fact which makes it necessary to pass over long intervals before looking for a change in the observed horizon. While this simplifies the problem, it leaves out of the account the possible changes that may exist in the character of the sedimentation on any geological horizon, and introduces an element of uncertainty in any attempt to generalize the rocks of the Cretaceous. Future observations made in detail in the various counties crossed by the Minnesota and its tributary valleys, will throw very much light on the question of the superposition of the outcropping members that have been seen the past season. The following arrangement is altogether provisional, and is intended to express such superposition as seems to be correct, in the light of the information now at hand.

In descending order.

1. Shale holding gypsum. Big Stone lake.
2. Clay and lignite clay. Crow creek and Redwood Falls.
3. Concretionary marl. Sec. 10, T. 112, R. 34.
4. Potter's clay. New Ulm and T. 110, R. 31.
5. Dauffenbach's fire-brick section. Waraju river. (perhaps the sandstone seen near Red Jacket mills, and at Garden City, belongs here.) (p. 133).
6. Limestone and shale. Winkelmann's quarry, near the mouth of the Waraju river.
7. Sandy shale. Gruebel's section, sec. 2, T. 109, R. 30
8. Sandstone. Fritz's quarry, sec. 16, T. 109, R. 29.

(k) *The drift, and the general topography of the valley.*

Southwestern Minnesota is characterized by extensive drift deposits. They are spread so evenly over the whole country, that to the eye of the traveler, there are but few important variations from a dead flat. One vast plain seems to spread out on all sides. The view is only obstructed by the narrow timber belts that skirt the valleys of streams, or by the dim haze in which the horizon is itself lost to sight. There are minor irregularities of surface due to the occurrence of gravelly knolls, and to the erosion wrought in the surface by streams of water, but these do not effect materially the general flatness of the whole region.

The general composition of the drift is such as to prove its origin to have been due to glaciers. By far the largest part consists of "blue clay," the surface of which is weathered to a yellowish brown to the depth of 15 or 20 feet. This contains gravel stones and boulders, yet it is nearly, and often quite, impervious to water. There are places, especially along the immediate valleys of the principal drainage courses, in which the drift shows a very sandy and gravelly composition, the sand and gravel being deposited in oblique and vanishing layers often to the depth of over fifty feet. This character is very common along the Minnesota from Mendota to Mankato. In this case the main bluffs of the river constituting the principal, and the first, descent from the prairie level, are made up of such stratified deposits, but at a short distance from the river valley, in either direction, the typical unmodified glacier drift returns with its full development.

Besides these instances of stratified gravel and sand in the drift along the immediate river valleys, isolated knolls, or clusters of knolls, composed of the same materials, are sometimes seen rising boldly and conspicuously from the midst of the level prairie, reaching all hights up to a hundred feet or more. Such knolls are sometimes ferriferous, and the gravel is hardly cemented, making a crag, with lumps of impure bog-ore. This ore is not now properly a bog-ore, since it lies on the sides of gravel knolls, one or two hundred feet high, (as on the Maple river, near the Red Jacket mills,) but it is probably a brown hematite. It is very siliceous and not likely to be of economical value. These gravel knolls are sometimes very stony, with northern boulders. Instances of such gravelly, rolling tracts, sometimes of large extent, were noted in the reconnoissance

made the past season, as follows: A belt of gravelly knolls runs from the southeast part of Faribault county, to about the center of the same. South from Lura it may be seen across the treeless prairie, and is scantily wooded. It furnishes the only stone useful for building or for foundations, in the form of northern boulders, that can be found throughout a wide extent of country. This gravel belt rises considerably higher than the village of Wells, and probably gives source and head to the artesian overflow of water that there exists. These artesian wells are 115 feet deep, and passed through "blue clay." In about the center of T. 110, R. 32, is a gravelly ridge or succession of drift knolls, running NNW., showing boulders on the surface. The country about is flat and prairie like, covered with the hard-pan, glacier drift, and these knolls are quite a relief to the eye. One can hardly resist the conviction that rock *in situ* must occur somewhere exposed in these knolls, and it is only after a lengthy examination that their true character is established. This ridge runs about a mile east of Sleepy Eye village, and the separate knolls rise 25-40 feet. They lie about on the strike of the red quartzite from New Ulm. The eastern ascent of the Coteau des Prairies enters Minnesota from the NW., in the southwestern part of Yellow Medicine county. East of this ascent about ten miles is a range of gravel hills running nearly N. and S., known at their southern extremity as the "cobble knolls," and at their northern as the "antelope hills." They are composed, as their name indicates, of drift. They have a general extension N. and S. but yet they occur in clusters. Some are quite sharp and abrupt. They rise from 125 to 200 feet above the surrounding prairie. They are smoothly rounded on their summits, and overstrewn with stones and boulders, the latter showing frequent glacial surfaces, even on the top. The grass and weeds are short. The soil is thin. Little gravel stones almost cover the surface. The knolls themselves consist largely, without doubt, of stratified gravel and sand, like a great many others that have been seen in different parts of the drift latitudes. (*Geol. of Iowa*, 1870, *Vol.* 1, *p.* 99: *Geological Survey of Ohio*, under Hardin, Allen, Delaware and Angalaize counties: *Proceedings of the American Association*, 1872, *p.* 164.)

They can be seen to extend six or eight miles, and perhaps are traceable further than that distance. From their tops a magnificent view of the prairies on all sides, and of the Coteau toward the west, can be had. A similar range

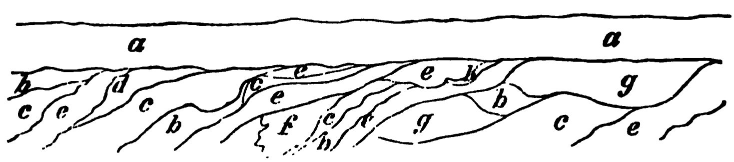
of drift knolls, but much smaller, was seen about six miles east of this range, running also in the direction N. and S. For reasons that cannot be here enumerated, these gravel ridges are believed to mark the location of the strike of different formations of rock, which, with each other, formed such inequalities in the surface passed over by the great glacier as to fracture the ice profoundly. The streams of water that entered and ran through such cravasses were sufficiently powerful to wash out the clayey portions of the drift, and to arrange the coarser in various stratification. After the withdrawal of the ice, the ridges of gravel mark the general location of such glacial streams. These must not be confounded with other drift ridges that accumulated about the borders of the ice field, known as moraines, of which the Coteau des Prairies seems to be a stupendous example. This remarkable topographical phenomenon was visited at the point where the Winona and St. Peter R. R. meets it. The country from Lac qui Parle to that place is of the same general character as the rest of southwestern Minnesota, but is perhaps freer from sloughs and impassable places than the country in the region of the Silurian rock. It is mostly entirely destitute of timber. The Lac qui Parle and its tributaries are wooded a few miles from the Minnesota, but very sparsely. The timber entirely disappears before reaching the state line. The soil shows in dessicated places the color of the alkaline deposit common on the western plains, becoming more and more abundant toward the west. There is not, enough, however, in this direction within the state of Minnesota to interfere seriously with agriculture or stock raising. The productiveness of the soil seems not to be affected by it. The state line, where the Winona and St. Peter R. R. passes it, is a short distance west of the foot of the *coteau*. At a distance the *coteau* looks like a sudden and marked elevation in the western horizon, rising a great hight above the prairie level. But on reaching it the ascent is found to be gradual, the surface changing from level to rolling or hilly. It is, however, quite abrupt in some places. Good farms can be laid out in neary all parts of the *coteau*, many of them far preferable to farms very highly valued in Ohio, Pennsylvania or New York. There is no timber except along the tributaries of the Lac qui Parle, or other small streams. No rock can be seen *in situ*. Although the railroad affords very frequent cuts in getting through this rolling country, it discloses no known rock as far westward as lake Cam-

peska. This point was particularly examined for over six miles beyond the foot of the *coteau*, with the hope of seeing, in some of the frequent cuts, some indication of a rocky sub-structure. Nothing can be seen but drift. This drift consists of glacial clay. The surface is generally stony, especially on the tops and brows of knolls. Boulders of northern origin are very common. Some large fragments of Silurian limestone were seen, but generally the erratics are granitic. Beyond the first ascent to the knobs of the *coteau*, there is a stretch of less rolling country reaching westward about ten miles, when another still higher range of hills and bluffs appears. The divide, east of the Sioux river, is about fifteen miles west of the state line, at an elevation (by the Winona and St. Peter R. R.) of 1,448 feet above Winona. The ascent from the prairie level, a few miles east of the state line, to the top of the *coteau*, fifteen miles west of the state line, is about 650 feet. On the top of the high country are occasional pleasant lakes. At De Graff, just beyond the state line, in Duell county, Capt. H. H. Herrick burns lime from a dark surface deposit of tufa. This deposit shows impressions of leaves and twigs, and others that appear like rushes. It has some iron stains, and a trace of bituminous matter. It occurs in a number of places on the sides of the knolls, overlying the drift gravel and clay. The general appearance of the surface of the *coteau*, especially near its base, as well as the surface of the *antelope hills*, aside from this surface deposit of tufa, where no water is now running, indicates the former prevalence of a much greater amount of water running over it than now. The boulders and gravel that lie so thick on the top and upper slopes came from the drift, the clayey parts having been carried away by drainage. They are all water worn though not so but that the boulders sometimes show glacially striated surfaces. That this water was running, and not standing, is evidenced by the tufa, which is only deposited where the atmosphere has access, and by the manner of its occurrence, which is only on the lower slopes of the knolls, though at varying elevations, so far as seen. That there was vegetation near is proved by the leaves and other impressions. That the flow was of short duration, comparatively, is also proved by the universality and uniform character of the drift sheet, and by the lack of rocky outcrops. That the water which deposited the tufa was heavily charged with lime, is proved by the abundance of the deposit and by the coarseness of the [illegible]

closed impressions. That it was the same that washed the light drift from the tops and brows of the knolls, is evident from their associated occurrence. That this water was from the retiring glacier, which would inevitably have given off water of a milky color, stained with the fine debris and soluble portions of the rocks it had ground up in its course, is probable.

At St. Paul, near the St. Paul and Sioux City depot, the lower part of the drift is exposed in the excavated river bluff, and is chiefly hardpan clay (or glacier drift). It is conspicuously colored by the shale of the Trenton. The alternating blue shale and copper-colored hardpan drift show successive accretions with such regularity as to attract immediate attention. The bands slope at an angle with the horizon, the drift holding stones and occasionally large boulders, and the shale showing fragments of the bedded lamination not yet obliterated, as well as the usual fragments of *Chaetetes*. At a higher level is a heavy stratum of 25 feet, overlying the foregoing, consisting of gravel and boulders, with many pieces of limestone. The following diagram illustrates the alternation of materials in the drift at this place.

Section in the drift at St. Paul.



a.	Gravel with many stones, 25 or 30 feet.		
b.	Green, shaly clay.	25 feet above the river.	25 or 30 feet.
c.	Blue, shaly clay.		
d.	Greenish, shaly clay.		
e.	Red clay.		
f.	Brown drift clay, stony.		
g.	Ashen drift clay.		

The bluffs of the Minnesota require a special mention, as they form a very important element, not only in the topography of the southwestern part of Minnesota, but also in any description of the drift of that portion of the state and of the northwest. The level of the river itself, in the summer season, is about 180 feet below the prairie level. The water runs in a very winding course back and forth between

the bordering bluffs, the direction of which, not regarding the little angles caused by streams that enter the Minnesota, is very regular. They have some long bends, but in general maintain a remarkable constancy of direction and hight. The bluffs, especially on the north side, are often treeless. The bottom-land itself is very often treeless. On the south side, on the contrary, the river bottoms and the tributary valleys, as well as the slope of the main bluff, are usually wooded. Hence the abruptness, and at the same time, the regularity of slope, direction and outline, are most marked on the north side. These bluffs appear, superficially, to be formed of drift alone above Mankato.

Below Mankato the Silurian rocks are frequently seen exposed in them, causing long terraces at various altitudes. Throughout the whole length of the valley, boulders and stones of a northern origin are seen on the brows of these bluffs, and on their abrupt faces, or on the slopes themselves. They literally cover, sometimes, the Silurian terraces below Mankato, as at Shakopee, Louisville, Ottawa, St. Peter, Mankato and Judson. There is a good illustration of this in the terrace that extends along the east side of the river below Mankato, and also toward South Bend. Where the hard rocks of the Silurian lie deeper, the boulders that otherwise would be visible seem to have sunk into the softer alluvium. They are always met with in penetrating through the alluvium, before striking the rock. They pertained to the general sheet of drift, before the excavation of the valley, and have been left simply lodged where they may have fallen, sometimes on rock terraces, as the river has slowly carried away the fine clayey portions of the drift. Notwithstanding the drift characters are the only apparent ones, yet there is a canopy of Cretaceous that lies below and gives levelness to the country, hiding the granite and the Silurian rocks. This, mixing with the drift, has greatly augmented its volume beyond what it would have been had harder rocks existed in western and southwestern Minnesota. The existence of this canopy of Cretaceous under the drift is demonstrated by the occasional exposure of such beds in the little ravines that enter the Minnesota. Such beds are intersected by the bluffs themselves, and cut by the river channel, though they are rarely seen in the main bluffs of the river itself. They are hid by the downfalling of the drift. They are so frail themselves that they cannot endure the exposure exhibited by the Silurian limestones, (see page 184,) and hence do not make

so manifest terraces in the main bluff. This main bluff, therefore, above Mankato, generally exhibits a regular slope from the prairie to the bottom land. There is sometimes a dim outline of a terrace, or shoulder, in this slope, caused by the unequal demolition of the Cretaceous, but *throughout the valley there are no alluvial terraces that can be attributed to successive reductions in the volume of the river.* Such appearances are visible at New Ulm, as well as at various places below Mankato, at Lower Sioux Agency and at Beaver Falls. At places below Mankato the semblance to constant terraces is due to the effect of the Shakopee limestone on the banks, combined with that of the erosible nature of the underlying Jordan sandstone. Such occasional benches occur at different elevations as far as the Silurian rocks extend. Above that they are due to the Cretaceous. Such occur at Fritz's quarry, a few miles below New Ulm, and at Gruebel's a little further up the river. At the former place a sandstone in the Cretaceous offers a more persistent obstruction to the water, at the latter the terrace is caused by a hard clayey layer over one that is soft and arenaceous. At New Ulm a similar combination of layers may be seen near Dauffenbach's pottery, and in some of the highway cuts for grading the streets running down from the city (which is situated on this terrace) to the R. R. depot. At and below Redstone, and on the opposite side of the Minnesota near the mouth of the Waraju river, a calcareous member of the Cretaceous causes a terrace that rises about 40 feet above the river. This may be seen at Winkelmann's lime kiln and quarry. This terrace is prolonged for several miles below Redstone, on the north side of the river. Its level for some distance is kept up by the red quartzite in outcrop there, but it is doubtless due mainly to the Cretaceous.

At Lower Agency a dim outline of a terrace is seen near the top of the bluff running along about half a mile. Its cause is not discoverable, but may be reasonably regarded some member of the Cretaceous, which can be seen at a lower level in the highway ascending from the ferry to the top of the bluff. It is most observable from a distance, and especially from the north side of the river.

There is a semblance at Beaver Falls, though faint, of two terraces, near the top of the bluff, visible from the opposite side of the river, the upper one having about the position of the faint terrace seen at Lower Sioux Agency.

A terraced condition of the bluffs may be seen at a little lake, caused by the enlargement of the river on T. 120, R. 44, as well as in the bluffs of Lac qui Parle. Here an observation was made that plainly indicates the origin of these benches. They exhibit a slope or dip towards the S. E., running successively down to the bottoms, higher ones occurring in their places. This can plainly be seen from the opposite bluff. This slope is believed to be due, in like manner, to the dip of the rocks of the Cretaceous, though no outcrop of those rocks was seen at that place, the bluffs of the river and of all ravines being smoothly turfed over.

The general hight of the bluffs that enclose Big Stone lake is about 150 feet. They are treeless. Their crests are usually crowned with boulders. The only wood that is seen lies in the "gulches" or short ravines that enter the lake from both sides, and on the islands, some of which are densely wooded with small trees. There is also a thin, continuous row of small trees and shrubs growing on the immediate shore, just above the boulder-row. The bottom-land is usually not marshy but arable, constituting really the most desirable farms. It is first taken by settlers. It is wide enough for one or two good fields. The settler also has his garden and cabin on the low land invariably, and generally at the opening of some one of the little ravines, which afford water without digging*, and protection from the winter winds, as well as convenient fuel. Along this lake, also, are terraces that have a slope or dip striking across the bluffs. One may be seen at Mr. Hurley's, eight miles above the foot of the lake, where it can be traced three or four miles, passing, in that distance, down from union with the prairie level to the bottoms, or so far down as to be blended in the bottom land. A similar vanishing terrace can be seen on the Dakota side, from the bluff on the north side, about twelve miles above the foot of the lake, and midway between Hurley's and Mireau's. Within the space of about three miles, its form can be seen to pass obliquely across the face of the main bluff, from top to bottom, sloping to the east or southeast, and disappearing in the bottom-land. A similar terraced appearance has been described as occurring at Brown's Valley, at the head of Big Stone lake, in connection with an exposure of the Cretaceous (see p. 190.) The interval between Big Stone lake and lake Travers (6 miles) has a fall toward Big Stone Lake of six feet. The bluffs approach each other toward the end of the lower

*The water of the lake is [illegible] and apparently deep.

lake, but do not unite. A continuous valley, between bluffs of the same form and appearance, and of nearly the same depth, connects the two lakes, giving the impression of one valley instead of two. The short interval constituting the divide between the two lakes is usually without water, but is often overflowed by the spring freshets, when a continuous overland watercourse is established between the gulf of Mexico and Hudson's bay, in British America. It was on one of these occasions that the attempt was made by the late Hon. Joseph R. Brown,* to float a steamboat from the Mississippi to the Red river of the North. Its remains still lie a few miles below the foot of Big Stone lake, where it was wrecked by the unexpected subsidence of the water. There is a very perceptible ascent in the smooth surface of the prairie, toward the north, from the bluffs of Big Stone lake.

Several points have been mentioned at which local terraces have been seen along the valley of the Minnesota river. They are occasioned, as has already been said, by the varying resistance of the underlying rock, when undergoing erosion by the river. This is evident from the following facts:

1st. They have a varying elevation, corresponding with the dip of the formation which causes them. They occur near the level of the flood-plain, blending sometimes with it, and also at all hights, to near the top of the bluffs.

2nd. The rock itself can be seen at many of the places where such terraces have been observed; and where it has not been seen, the face of the bluff has been unfavorable for exposure, the surface being smoothly turfed over.

3rd. There are hundreds of miles along the river, on both sides, where no such terraces can be seen, the bare bluffs being smoothly rounded off, and descending at one change from the prairie level to the flood plain. Indeed, the existence of terraces is quite an exceptional thing.

4th. In many cases, the terraces can be referred directly to their cause, layers of varying resistance in the Cretaceous.

5th. Where there is no rock in the river banks, as shown by fresh slides, there is no appearance of terraces.

A short distance below Minnesota Falls the bluff rises, on the north side, 159 feet 1 and ⅞ inches above the flood plain, measured by Locke's level.

There is an old valley of the Minnesota river, extending from Lac qui Parl lake eastwardly, and joining the Chippewa valley about five miles above its mouth. This old valley has bluffs like the present river valley, but it is not

*It was Capt. John B. Davis, see vol. I, of the final report, p. 134. (N. H. W.—1885.)

quite as deep. It is nearly dry, a little water standing only in one or two spots, near the west end, and slowly passing into the Minnesota, the bottom being a level and handsome meadow. The appearance of this valley is rather novel and striking. The slopes are perfectly treeless, and very smooth, luxuriantly covered with grass and ornamented with flowers of various colors. There are short ravines or "gulches," that descend from the prairie, but they do not show a tree, nor a shrub. They are smoothly grassed over, and near their mouths can be crossed with a team. The bluffs themselves, though often overstrewn with stones and coarse gravel, are yet composed of hard drift clay, and are rarely too abrupt to be ascended by a horse. Toward the west end of this old valley the slope from the prairie shows a terrace about thirty feet from the top, but nothing can be seen on it, or even in the excavation cut for the road, but drift materials, though boulders are rather more numerous at that point in the cut than above or below. Below the level of this bench, twenty feet, is a row of springs which keep the rest of the slope wet and soft. The whole appearance, taken together, indicates a stratified condition of the bluff, probably in Cretaceous rock.

THE ECONOMICAL GEOLOGY OF THE MINNESOTA VALLEY.

Coal.

The separation of the region of the Minnesota valley from all the important coal fields, and its comparatively sparse supply of wood for fuel, have directed the attention of the settlers to the possible supply of fuel from the lignites of the Cretaceous. Mention has already been made of the localities of outcrop of this coal (pp. 221-224) with some description of the modes of its occurence. The subject has also been summarized in the letter to the President introductory to this report. There are coal deposits of the Cretaceous age that are likely to prove valuable. They occur at various places, scattered over the western territories. Such coal is also sometimes in the condition of good anthracite. A valuable bed of coal is reported to exist a few miles west of Bismarck, on the Missouri river. There can be but little doubt that such or similar coal accompanies the lower Cretaceous rocks throughout their extent in Minnesota. From the wide extent of territory in which "float coal" is found in the drift, it seems very probable that the Cretaceous

ocean at first covered the most of the state. So far as discovered, however, there is not enough coal embraced in the Cretaceous, in this state, to warrant sanguine expectations of its becoming economically useful. This coal occurs in two distinct forms, which may be distinguished, until further investigations demonstrate some error in the designations here given, as *charcoal* and *cannel coal*. The former, while it is the more abundant, is of less value for use as fuel. It is light, and quickly ignites, but it is generally in fine pieces that appear to be matted down with the ash that resulted from the combustion of other portions of the wood from which the coal is derived. It lies in irregular sheets generally, not more than half an thick when pure, but may be disseminated through a thickness of six or eight feet. It is very fragile, hardly bearing transportation. The latter is black, or brown-black, lustrous, compact, rather hard, and presents every aspect of a valuable coal. It occurs in isolated lumps or pockets, in the same beds as the charcoal, but less abundantly. It readily burns, making a hot fire. In the air, when it has become dry, it cracks and crumbles something like quick lime, but not to a powder. It is this which is found in the drift. If it could be found in sufficient quantity, this would be a valuable fuel.

The Iowa coal field, of Carboniferous age, does not reach as far northwest as the valley of the Minnesota.

Iron.

The only iron ore that is known to occur in southwestern Minnesota, is in the form of an imperfectly hydrated peroxyd, or brown hematite. It is, so far as seen, so impure as to constitute a clay iron-stone. It was first mentioned as occurring on the Le Sueur, a mile and a half above its mouth, by Dr. B. F. Shumard (Owens' Report, p. 487), who describes it as "nodules of oxide of iron, and argillaceous iron ore," and gives it a thickness of two feet, remarking that: "The superficial indications render it probable that this bed of iron ore may be both extensive and readily accessible." Similar indications of iron ore were seen the past season at a number of places on the Le Sueur and on the Watonwan. So far as observed, however, the iron seems to be largely, if not entirely, superficial, and pertains to the horizon of separation between the drift and the bedded rock. It is a circumstance of frequent occurrence, in all parts of the northwest, to see ferriferous

springs issuing from the gravel of the drift. When such water comes in contact with the air it invariably gives an iron stain to substances over which it runs. If the process be continued a brown hematite iron ore will be formed. It will partake of the impurities of the surface on which it forms. There is besides a considerable thickness of argillaceous iron-stone that coats the Silurian limestones, when they are found overlain by the clays of the Cretaceous (see pages 133 and 179.)

Mineral paint.

At Redwood Falls the kaolin which has resulted from the decomposition of the granite rock, has become stained with iron, and has a brownish or greenish-brown color. It contains, generally, some silicia. From this stained kaolin a good mineral paint has been manufactured. Messrs. Grant and Brusseau commenced the enterprise, and carried it far enough to demonstrate the quality of the product. The manufactured article is said to have been equal to that of Brandon, Vt., but that the cost was so great that, after transportation to St. Paul, it could not be offered in the market as cheaply as the Brandon paint. Their process was very simple. The raw material was obtained from the banks of the Redwood river (p. 168), and was of a rusty-brown color, having also a greenish tinge. It was broken, or crushed to the fineness of corn or wheat. It was then dried in a large pan placed over a fire, and ground by water-power, between two burr stones. In that condition it was ready for use by simply mixing with boiled or raw linseed oil. It was found that lead or ochre could not be used to advantage with it. The lead is said to have "come out and looked like a mildew." The color produced was a reddish umber. By making some selections various lighter shades, of the same general character, were produced. It had a heavy sediment, consisting probably of iron and silica. The quality of the paint is said to have been superior to that from Ohio, and fully equal to that from Brandon, Vt., or Horicon, Wis. The surface of the wood painted, becomes hardened and glazed, but remains smooth.*

It is evident that the best methods for economy were not employed in this enterprise. The mine is situated about a mile from the mill. The rock is easy of access. It cost a

*The mills of Worden, Ruter & Co., at Redwood Falls, and of Austin & Worden, at Minnesota Falls, are painted with it.

sum between three and four dollars per ton to deliver the raw material at the mill. It could probably be done for less than a dollar. The total cost of manufacture ought not to exceed a dollar per hundred, or twenty dollars per ton. The Brandon paint sells for about $40 per ton. These statements are on the authority of Mr. Park Worden, of Minnesota Falls.

Although the foregoing is the only systematic attempt that has been made to manufacture paint from this substance in the Minnesota valley, it occurs in great abundance at a number of places. It is also found in greater purity, at least with much less quartz and iron, at several other places. Indeed it seems to exist wherever the granitic rocks were buried beneath the ocean of the Cretaceous age, and where the glacier period has not disrupted it.

Quick-lime.

For common quick-lime the region of the upper Minnesota has no suitable stone. Here is a great extent of fertile country, destined to be thickly inhabitated, that must always depend on the Silurian limestones, situated further southeast, for one of its necessary articles of construction. At the present time the only resort is to the limestone boulders that occur in the drift. These are being rapidly gathered up and converted into quick-lime, and will soon entirely disappear. The nearest Silurian quarries capable of being useful for quick-lime are at Mankato. The limestone found in the Cretaceous at New Ulm is also very valuable to this region, but the shaly nature of the stone there will always make it difficult to compete with the lime from Mankato. At the same time the quality of the lime made there renders it applicable to uses of which the Mankato quick-lime is not susceptible. The Mankato lime is of a dark leather color, slacking to a cream color. It has a considerable sand that appears as a sediment. The stone itself is an arenaceous magnesian limestone, and the lime partakes of the nature of those limes. It sets more slowly, burns more easily, and slacks with less heat than the pure limestones. It is useful for brick and stone work, but will not answer for hard finish. For common brown plastering it is very useful. The lime made at New Ulm, on the other hand, is nearly white, and in that respect has the advantage of the Mankato quick-lime. It is very hot, and sets quickly. It is more nearly a pure lime, without magnesia. While it

has no sand, as an impurity, it has alumina. Associated with it in the shales of the Cretaceous, is more or less of sulphate of lime in the form of transparent crystals, or selenite. When there is much of this it would materially affect the quality of the lime, giving it somewhat the character of plaster of Paris. Below Mankato there is no lack of good stone for quick-lime. The Shakopee limestone is calcined at a number of places, and outcrops in the banks of the river at a great many others.

At Shakopee the kilns are owned by Baptiste Contre and Isaac Lincoln. They are constant, or "draw kilns." Mr. Contre burns from 17 to 18 hundred barrels per month, and seven months per year. His markets are St. Paul, Minneapolis and St. Cloud, in bulk, two hundred pounds making a barrel. Lime is produced in 30 hours. Wood costs two or two and a half dollars per cord, mixed. He "draws" every six hours.

Mr. Lincoln's kiln is considerably larger than Contre's, and requires from two to four days to produce lime, which sell at the kiln at 75 cents per barrel, twenty-two or twenty-four hundred barrels being produced per month, during seven or eight months of the year. The lime made at Shakopee is of a leather color, sometimes approaching burnt umber.

At Louisville, five miles above Shakopee, Mr. Contre owns another kiln similar to that at Shakopee. Mr. Folsom, of Minneapolis, also has a kiln here which is in operation some portions of the year. The lime produced here is of the same character as that at Shakopee. It is shipped to St. Paul, Minneapolis, and occasionally to Duluth and St. Cloud. Four or five cords of mixed wood, at two and a half dollars per cord are required for each hundred barrels.

John P. Rinshed burns lime from the Shakopee stone, at Ottawa.

About a mile above Kasota Conrad Smith burns lime from the Shakopee limestone, which he sell at one dollar per barrel. Eight or nine cords of mixed wood, at $2.75 per cord, are consumed in producing 100 barrels of lime. He has a draw kiln, but not enough demand to keep it in constant blast. The lime is dark and in nearly all respects like the Shakopee lime. It shows a bluish tint, and, Mr. Smith says, slacks to a *blue-white*, instead of a *yellow-white*, and is preferred for that reason.

Five miles below Mankato George C. Clapp burns a lime that is bluish, or ashen colored. He takes the stone from

the upper portion of the Shakopee limestone, and produces a purer lime than any seen in the valley, except that derived from the Cretaceous at New Ulm, which probably comprises over 80 per cent. of pure carbonate of lime. Mixed wood costs here $2.25 per cord, and five or six cords are required for a hundred bushels. (See page 144.)

At Mankato, besides the kilns of Maxfield & Sons, Capt. J. R. Beatty has recently erected a fine draw kiln.

At New Ulm are the lime-kilns of Wm. Winkelmann, Francis Baasen and John Heiman, all burning lime from the Cretaceous. Winkelmann burns about 1800 barrels per year, selling at the kiln, and at New Ulm, for $1.50 per barrel. It here requires 20 cords of mixed wood, at $3.00 per cord, to produce 120 barrels of lime. When freshly burned this lime has very much the same color as the stone, though a little lighter, and slacks white. His kiln stands on the bank of the Minnesota, facing the water, and is built of red quartzite and boulders. Mr. Heiman's kiln holds 150 barrels. Forty cords are needed to burn the kiln well, when filled. Wood costs $2.50 or $3.00 per cord. Lime sells at a dollar or a dollar and fifteen cents per barrel.

Above New Ulm boulders only are used for lime, the kilns being of rude construction. Such are owned by John Edget and Charles Folsom, a short distance below Beaver Falls, and by Andrew Brandin, M. C. Brace, Wm. Davis and brother, ——— Brennan, and R. R. Cory, above that place. Large limestone boulders occur about Redwood Falls. At Yellow Medicine the only lime made is derived from large boulders. Peter Casting burns a little lime from such boulders at Jannetteville, nearly opposite the mouth of the Yellow Medicine. At Granite Falls such boulders, occurring in a little ravine on the land of R. H. Baldwin, have been taken for rock *in situ*. At Mr. Hurley's, eight miles above the foot of Big Stone lake, excellent quicklime is burned from surface boulders, some of which is marketed at Morris, in Stevens county.

Gypsum.

The Cretaceous, at Big Stone lake, holds large crystals of selenite. They lie on the surface of the weatered slope made by the outcropping of a dark shale, and can be gathered in considerable quantity. They are, of course, embraced within the shale. From the existence of sulphate of lime in quantities that render it of economical importance

in this formation in various parts of the country, it is presumable that this horizon of outcrop is nearly, or exactly the same; and that at some future time, when sufficiently detailed exploration has been made, it may here prove equally valuable. This place has been already described under the head of the Cretaceous.

Fire clay.

From the Cretaceous, near New Ulm, Mr. Christian Dauffenbach manufactures a good fire brick. The bank from which he takes the clay is fifteen feet above the river. It is of light color and when wet is plastic, but if dry it is hard and difficult to quarry, the use of powder becoming necessary. Horse power is used for his machinery. He has three kilns. This fire brick clay lies below a heavy stratum of white sand. If the white sand that occurs on the Maple, a few miles above its union with the Blue Earth, be the same horizon, this fire clay ought also to be found in the banks of the Blue Earth, a short distance above its mouth. In the settlement and material development of that part of the state, this stratum in the Cretaceous is destined to play an important part. (See page 185.)

Potter's clay.

The Cretaceous also supplies, near the same place, but from a higher stratum, a good potter's clay, which is largely employed at New Ulm and at Mankato. It is owned by Silas Barnard. Mr. H. B. Kaufer, potter at Mankato, regards it as equal to the Carboniferous potter's clay of Ohio. The manufacturers at New Ulm are Winkelmann and Dauffenbach, and John Stoerket. The pottery sells for twelve and fifteen cents per gallon. (See page 186.)

Kaolin or China clay.

It has been said already, in connection with the description of the granites of the valley, that the upper surface of the granites, where protected by the Cretaceous, is overlain by a heavy bed of kaolin clay, resulting from the decomposition of the granite itself. There can be no question but that this deposit, or rather kaolinized granite, since it is decomposed and lies *in situ*, will become of great economical importance. Kaolin is not a common mineral in the drift

latitudes. It is common in New Mexico, where the granite is likewise found to be decomposed to the depth of 50 or more feet. It is also found in the Blue Ridge in Virginia, the mountain rock there being changed to impure kaolin to a considerable depth.* Although the purity of the kaolin of the Minnesota valley has not been established by tests, either practical or chemical, it is highly probable that some portions of it, at least, will be found to answer all the purposes for which such clay is generally used.

Building stone.

For construction, the Shakopee limestone holds at present a high position in the regard of builders. Its best estate is not seen at Shakopee but at Ottawa, Kasota and St. Peter. The Mankato quarries are equally as fine. The quarries at Kasota show a deeper shade of pink than those at any of the other foregoing places. The best stone yet furnished by this formation, was that put into the recent enlargement of the asylum at St. Peter. It was taken out near the asylum, and lies in very heavy and regular layers. The quarries at Kasota and at Ottawa have not yet penetrated so deeply into the rock, but will prove to be thicker bedded as they are further wrought. The Episcopal church at St. Peter, made of this stone, has a dark brown cornice, window frames and blinds, and the wall is painted dark-brown, making, although perhaps too somber, yet a very tasty and appropriate edifice for worship. It is low, and of gothic build.

South from Mankato, on the Blue Earth, the Maple and the Watonwan, are several very favorable openings, but there has not been much working in this stone, nor in any other, in that part of Blue Earth county, the dependence being entirely on the quarries at Mankato. There is no reason, however, why the counties of Martin and Faribault may not derive all their stone for walls and for all building, from these southern quarries, saving themselves the labor of transportation six or ten miles. Stone from these quarries was used in the culverts and bridge piers along the new railroad from Mankato to Wells. At Garden City, the exposure in the bed of the river is owned by J. Willard. This outcrop has more the aspect of the Shakopee limestone, at Shakopee, than any other seen,

*Compare *Am. Jour. Sci. and Arts*, III, Vol. VII, p. 74.

and will not be found to furnish as handsome layers as the quarries at Mankato.

At Jordan, the sandstone lying next below the foregoing limestone is somewhat employed for foundations, and has been put into some large buildings. It cuts well, and is in blocks about eight inches thick. It is rather too friable, however, for general use.

The St. Lawrence limestone is a very fine stone for building. It is tough, compact, and of a good color. Its bedding is symmetrical and of convenient thickness. The only quarries known are those at St. Lawrence and at Hebron and Judson. The Presbyterian church at Belle Plaine is built of the St. Lawrence stone, the trimmings being from Ottawa. In the Potsdam at Redstone, quarries are opened by Francis Bassen, Wm. Winkelmann and Frederick Meyerding.

Of the granites and associated rocks there is a great variety. There is also every desired facility for quarrying them. The "gray" and "red" granites afford every kind of shading of color, and a great many beautiful combinations of mineral contents and crystallization. The time cannot be far distant when a great many valuable openings will be made in the granites of the Minnesota valley, for the convenience of the southern part of the State and of Iowa.

Brick.

Common red brick, sometimes also brick of a lighter shade, are manufactured from the alluvium of the river at New Ulm and Mankato, as well as at other points further down the valley. The Mankato brick have a high reputation, and are extensively shipped to St. Paul. The makers are Meihofer and Whitrock, Reed and Mather, Jager brothers, and Mr. Schlafle. At New Ulm, Wm. Winkelmann owns the only brickyard. At Jordan, Charles Rodel makes a light-colored brick.

Copper.

At Shakopee a stock company exists for sinking a shaft to explore for copper. It is said that in sinking a common well pieces of native copper were found. The shaft is to be as deep as that well which, when vigorously pumped, is said to afford particles of copper with the water. The limestone was struck at 18 feet. The work has not progressed

far enough to indicate the probable result. The limestone at Shakopee being of the same age as Calciferous sandrock of the east, recalls the fact that they both belong to the Quebec group of Canada, which is regarded there as holding the upper copper-bearing rocks of lake Superior.

Timber and fuel.

"The big woods" of Minnesota, consist of a southward prolongation of the timber belt about forty-five miles wide, in the central part of the state. The boundary of this prolongation on either side, is not well marked, the trees gradually becoming thinner and smaller, and more and more restricted to the valleys of streams, till the country is changed to a treeless prairie. The surface itself is more rolling than on the east or west. It may be thus described in general: Beginning a few miles west of Minneapolis the eastern edge of the big woods crosses the Minnesota in a line towards Lakeville, in Dakota county. Continuing in a southerly direction, it passes about a mile east of Cannon City, and of Owatonna, when it makes a short bend to the west and northwest, passing about six miles north of Waseca, and near E. Janesville, in Waseca county. In Blue Earth county it is variously modified by the valleys that are tributary to the Minnesota from the south. Continuing west, about six miles south of South Bend, it turns north, and crosses the Minnesota. Running along the west side of the Minnesota, distant from it about four miles, it begins to bear off to the northwest at St. Peter, and runs in nearly a direct line to Darwin, on the St. Paul and Pacific R. R., bending a little to the east, toward Glencoe, in McLeod county. In passing through these woods from Farmington, in Dakota county, to Shakopee, in Scott county, the following species of trees and shrubs were seen. For ten or twelve miles after entering the woods very few trees are seen, the oak shrubs being the largest and almost the only tree-like vegetation. About half way to the Minnesota river the maple and large elms, bass and iron wood appear.

Oak shrubs. Apparently Quercus ilicifolia. *Wang.*
Hazelnut. Corylus rostrata. *Ait.* (?)
Bur oak. Quercus macrocarpa. *Michx.*
White oak. Quercus alba. *L.*
Wild red cherry. Prunus Pennsylvanica. *L.*
Trembling aspen. Populus tremuloides. *Michx.*
Sumac. Rhus typhina. *L.*
Choke cherry. Prunus Virginiana. *L.*

Wild plum. Prunus Americana. *Marshall.*
White ash. Fraxinus Americana. *L.*
Sumac. Rhus glabra. *L.*
Thorn. Cratægus.
Rose. Rosa blanda. *Ait.*
Juneberry. Amelanchier Canadensis, Var. Botryapium. *Torr. and Gray.*
Round-leaved cornel. Cornus circinata. *L'Her.*
Common elder. Sambucus Canadensis. *L.*
American crab-apple. Pyrus coronaria. *L.*
[The young twigs and the under surface of the leaves are very woolly-pubescent.]
Black cherry. Prunus serotina. *Ehr.*
Frost grape. Vitis cordifolia. *Michx.*
American elm. Ulmus Americana. *L. (Pl. Clayt.) Willd.*
High bush cranberry. Viburnum Opulus. *L.*
Two or three species of willow. Salix.
Green ash. Fraxinus viridis. *Michx. f.*
Prickly ash. Zanthoxylum Americanum. *Mill.*
Cockspur thorn. Cratægus crusgalli. *L.*
Red raspberry, Rubus stirgosus. *Michx.*
Black currant. Ribes floridum. *L.*
Cottonwood. Populus monilifera. *Ait.*
Large-toothed aspen. Populus grandidentata. *Michx.*
Bass. Tilia Americana. *L.*
Red mulberry. Morus rubra. *L.*
Ironwood. Ostrya Virginica. *Willd.*
Sugar maple. Acer saccharinum. *Wang.*
Soft mapel. Acer rubrum. *L.*
Alternate-leaved cornel. Cornus alternifolia. *L.*
Bitternut. Carya amara. *Nutt.*
[Rare east of Spring Lake.]
Butternut. Juglans cinerea. *L.*
[Very rare except at Spring Lake and westward.]
Slippery elm. Ulmus fulva. *Michx.*
Staghorn sumac. Rhus typhina. *L.*
Tamarac. Larix Americana. *Michx.*
Box elder. Negundo aceroides. *Moench.*
Wolfberry. Symphoricarpus occidentalis. *R. Br.*
Panicled cornel. Cornus paniculata. *L'Her.*
[The most common species of *Cornus.*]

In ascending the valley the following additional species were seen:

Kentucky coffee tree. Gymnocladus Canadensis. *Lam.*
Red cedar. Juniperus Virginiana. *L.*
Black walnut. Juglans nigra. *L.*
Hackberry. Celtis occidentalis. *L.*
[The hickory grows to about six inches in diameter and then is invariably winter-killed. A tract of many acres is now being cut near St. Peter for fuel, having been killed the past winter. All the trees are small. The hackberry is used for fuel, and for furniture. It is commonest in the heavy timber. The butternut is rarely large. The box-elder sometimes exceeds three feet in diameter.]
Blue beech. Carpinus Americana. *Michx.*
Yellow or gray birch. Betula lutea. *Michx. f.*
[There is said to be a species of locust at St. Peter, but it has not been recognized by the survey. The above species of birch has oblong catkins, and spreading lobes on the scales which are 3 inches long. The lobes are obtuse.]

The trees and shrubs of Big Stone lake.

At Mr. Hurley's, eight miles above the foot of Big Stone lake, on the north side, the following trees and shrubs were seen growing:

Trees—In the order of abundance.

White ash. Fraxinus Americana. *L.*
Bur oak. Quercus macrocarpa. *Michx.*
Basswood. Tilia Americana. *L.*
Elm. Ulmus Americana. *L.* (*Pl. Clayt.*) *Willd.*
Box elder. Negundo aceroides. *Moench.*
[This makes a very fine "maple sugar" and syrup. It is abundant on the islands.]
Cottonwood. Populus monilifera. *Ait.*
Hackberry. Celtis occidentalis. *L.*
Ironwood. Ostrya Virginica. *Willd.*
Soft maple. Acer rubrum. *L.*
Wild plum. Prunus Americana. *Marshall.*
Slippery elm. Ulmus fulva. *Michx.*
Willow. Salix nigra. *Marshall.*

Shrubs.

Grape. Vitis æstivalis. *Michx.* (?)
Gooseberry, (prickly). Ribes Cynosbati. *L.*
Gooseberry, (smooth). Ribes rotundifolium. *Michx.*
Wolfberry. Symphoricarpus occidentalis. *R. Br.*
Black currant. Ribes floridum. *L.*
Prickly ash. Zanthoxylum Americanum. *Mill.*
Red raspberry. Rubus strigosus. *Michx.*
Black raspberry. Rubus occidentalis. *L.*
Sweet elder. Sambucus ?
Sweet viburnum. Viburnum Lentago. *L.*
Red osier dogwood. Cornus stolonifera. *Michx.*
Bittersweet. Celastrus scandens *L.*
Choke cherry. Prunus Virginiana. *L.*
Red rose. Rosa lucida. *Ehr.* (?)
White rose. Rosa blanda. *Ait.*
Virginia creeper. Ampelopsis quinquefolia. *Michx.*
Waahoo. Euonymus atropurpureus. *Jacq.*
Smooth sumac. Rhus typhina. *L.*

[The list of plants of Minnesota by Dr. I. A. Lapham, alluded to in the address to the president, is withheld for future publication.]

INDEX TO THE GEOLOGICAL REPORT.

THE

LOGICAL AND NATURAL HISTORY

VEY OF MINNESOTA.

; THIRD ANNUAL REPORT

FOR THE YEAR 1874.

[SECOND EDITION.]

Y N. H. WINCHELL, STATE GEOLOGIST.

) TO THE PRESIDENT OF THE UNIVERSITY Dec. 31, 1874.

MINNEAPOLIS:
HARRISON & SMITH, PRINTERS.
1894.

[NOTE—This edition is identical with the original, ex-
ing the correction of typographical errors. As this re
was published originally only as part of the regents' re
it has the paging of that report.—N. H. W.]

ADDRESS.

the President of the University:

'he regular work of the geological and natural history vey of the state was interrupted during the season of 4. The condition of the new buildings at the Univer- has been such that no chemical work could be satisfac- ily done, and very little has been accomplished. The ie cause deranges the geological laboratory and delays the acking and examination of specimens. Not a room has n available during the season for opening and unpacking :es.

t the close of the spring term in the University, the rd of regents granted the request of Col. Wm. Ludlow, 3. T. E., and allowed the departure of the state geolo- with the expedition of general G. A. Custer to the Black s of Dakota. He was absent during July and August. s again broke in upon plans that had been laid for a rous prosecution of the field-work of the state survey. regents, however, rightly regarded the exploration and elopment of the Black hills of Dakota as largely tribu- to the state of Minnesota, while the accessions that ld be made to the University museum were likely to e than repay the expense and time required. The young e of Minnesota also may claim the honor of sending the geologist through the unexplored interior of the Black s, so long involved in mysterious and legendary uncer- ty. A report on the geology of the route and of the ck hills of Dakota is herewith transmitted.* The prob- s that have long been debated by geologists concerning relative ages of certain sandstones of the Lower Silurian

y order of the Board of Regents this report has been transmitted to Col. Wm. ow.

receive some light by the geological examination of the Black hills, and some of the detailed sections of those rocks given in the accompanying report, are exceedingly interesting. Every facility, except a sufficiency of time, was placed at my disposal by Gen. G. A. Custer, through Col. Ludlow for the prosecution of the geological examinations. The expedition, being restricted to sixty days, and with provisions only for that length of time, was compelled to pass over the ground faster than was conducive to a full knowledge of the geology of the region traversed.

After my return from the Black hills, delayed somewhat by sickness in my family, and by the necessary preliminary work for the accompanying report, I had only time to complete the examination of two counties. I chose Freeborn and Mower, those being next the state of Iowa and within the possible coal area of Minnesota. A local interest has been excited in Freeborn county by the development of a shaft at Freeborn which was reported to go through several feet of good coal. This region has been thoroughly explored and the full details are contained in the accompanying report on that county. I am greatly obliged to Wm. Morin, Esq., of Albert Lea, for guidance and assistance in the survey of Freeborn county, and to Hon. A. A. Harwood, of Austin, for the same in making the survey of Mower county.

Various parties have submitted to the survey, for analysis, ores from the northern part of the state, and have applied for assistance in exploring those portions of the northern part of the state that are known to afford indications of the precious and useful metals. In some cases these samples of ores have been received and analyses have been procured, through the agency of the survey, by chemists abroad; but it has not been possible to afford any guidance to persons applying for assistance in field exploration. It is exceedingly desirable that the chemical laboratory, now nearly completed, be made available for the work of the survey, as soon as possible.

In the early part of the season, a pamphlet on *Peat as domestic fuel*, was prepared, at my request, by Prof. S. F. Peckham, the chemist of the survey, for general distribution. Several hundred copies have been gratuitously distributed to those citizens of the state interested in the subject of peat fuel, and it was printed in full by the *Farmers' Union*, the principal agricultural newspaper of the state. It was hoped thereby to give the needed information concerning the nature and outward characters of peat, to

farmers and others living in the treeless districts, that would enable them to discover and to make use of it as a common fuel where it exists, if they should feel so disposed.

During the season of 1873 but very little good peat was found in the counties of Jackson, Cottonwood and Nobles; but in the examination of Freeborn county, during the past season, inexhaustible quantities of the best qualities of fibrous peat were met with. Mower county contains very little.

Very respectfully,

N. H. WINCHELL.

THE UNIVERSITY OF MINNESOTA,
Minneapolis, Dec. 31, 1874.

REPORT ON THE GEOLOGY FREEBORN COUNTY.

Situation and area.

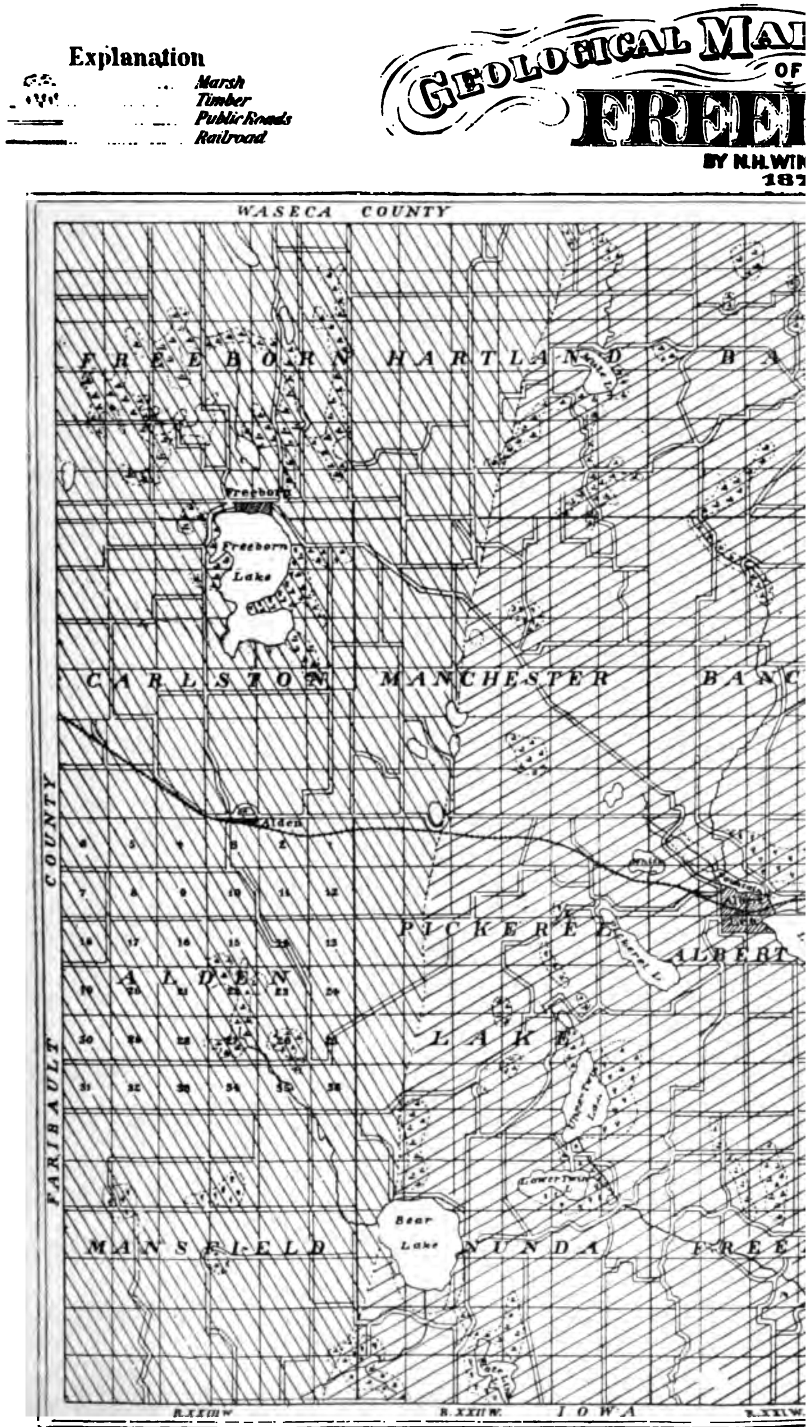
Freeborn county borders on the state of Iowa, ı very near the center of the southern boundary line oı nesota. It has the form of a rectangle, having a lı east and west, of five government towns, and nort south, a width of four, making an area of 720 square or 449,235.63 acres, after deducting the areas cover water.

Natural drainage.

With the exception of Freeborn, Hartland, and Char townships, the surface drainage is toward the sout southeast. The county embraces the head waters ı Shellrock and Cedar rivers of Iowa, and those of the river, which joins the Minnesota toward the north. it lies on the watershed between two great drainage s For the same reason none of its streams are large Shellrock, where it leaves the state, being its largest. streams have not much fall, but afford some water-p which has been improved in the construction of flı mills. Such are found at Albert Lea and at Twin I In these cases the body of water confined in the uppe serves as the water-head and reservoir, the mills bein structed near their outlets. There is also an availab ter-power at Shellrock village, but its use would cau flooding of a large body of land adjoining the river.

Surface features.

The surface of the county, although having no rema and sudden changes of level, yet is considerably dive as a rolling prairie, more or less covered with spars and oak bushes. The plats of the United States surv



Explanation
Marsh
Timber
Public Roads
Railroad
GEOLOGICAL MA
OF
FREE
BY N.H.WI
18
WASECA COUNTY
FARIBAULT COUNTY
FREEBORN
HARTLAND
Freeborn
Freeborn Lake
CARLSTON
MANCHESTER
Alden
PICKEREL
ALBERT
ALDEN
LAKE
Bear Lake
MANSFIELD
NUNDA
R.XXIII W.
R.XXII W.
IOWA
R.XXI W.

ile in the register's office at Albert Lea, indicate con- rably more area covered with timber, or as "oak open- ," when the county was surveyed by them, than is now case. The following minutes are based on an examina- of their plats, and will give a pretty correct idea of the ibution of the oak openings and the prairie tracts ughout the county.

ndon. The most of this township is prairie, a belt of openings and timber entering it from the north, about e miles wide, in the center of the town, and extending e center, bearing off to the SE., and terminating in 24. The magnetic variation throughout the town was, n surveyed (1854) from 8° 20′ to 10° 42′, the greatest g in secs. 33 and 34.

ıkland. A little more than a half of this township con- of oak openings, an area in the eastern half only be prairie, with a small patch also in sec. 31. Two large ghs cross the town, one through sections 30, 31 and 32, the other through sections 4, 5, 8, 7 and 18. Magnetic ations about 9°, varying from 8° 12′ to 10° 8′, in 1854.

oscow. Nearly the whole of this township is taken up oak openings and marshes. Turtle creek crosses it NW. to SE. A large portion of the northern half of own is a floating marsh, containing a great quantity of . Mag. var. from 9° 20′ to 10° 20′, in 1854.

wry. There is a small patch of prairie in the north- part of this town, secs. 1, 12, 13 and 24, and a small in secs. 20 and 21. There is another in the NW. cor- embracing sections 6 and 7, and parts of 5, 8 and 18. rest is openings and marsh, particularly of marsh in the corner. Mag. var. 8° 20′ to 9° 40′, in 1854.

ellrock. A belt about 1½ miles wide along the west of this town, accompanying the Shellrock river, consti- s the only openings or timbered portion, the rest being rie. This district also comprises some marsh, viz., secs. d 31. Th first house in the county was built in sec. n this town, in the SW. quarter. Mag. var. 8° 45′ to .5′ in 1854.

ayward. A wide belt of prairie occupies about two- ls of this town, running N. and S. through the center. he west of this is a rolling tract embracing a portion of Albert Lea and some tributary marshes, while on the a large marsh covers sections 12 and 14, and portions 3, 11, 15, 22 and 23. There is also a prairie tract in 1.

Riceland. This township is about equally divided between prairie, openings and marsh, the first being in the south central portion, the second in the northwest and central, bordering on Rice lake, and the marsh in the northeastern part of the town. Mag. var. from 8° 45′ to 10° 30′.

Geneva. There is but little prairie in this town, the southern portion being comprised in a large marsh which is crossed by Turtle creek, the outlet of Walnut lake. The central portion is occupied, by oak openings which also extend to the NW. and W. boundaries. The prairie is in the northern and eastern portions. Mag. var. 9° 10′ to 10° 23′ in 1854.

Freeman. This township comprises no prairie. It is mostly devoted to oak openings, but a series of marshes, drained by the tributaries of the Shellrock, that cross it toward the SE. take up a considerable area in the central and eastern portions. Mag. var. 9° to 10° 40′ in 1854, the greatest being in sec. 31.

Albert Lea. This township is nearly all taken up with oak openings, but a few small marshes, trending NW. and SE., are found in different portions. There is also a small patch of prairie in sec. 6, and another in the SE. corner of the county. The western arm of Albert Lea lake, through which the Shellrock river runs, is in the central and eastern part of this town, and adds greatly to the variety and beauty of its natural scenery. Pickerel lake is also partly in this township. Mag. var. 8° 46′ to 10° 08′ in 1854.

Bancroft. A little more than one-fourth of this township is prairie, situated in the center and southwestern portions. The rest of the town is covered with oak openings. The source of the Shellrock is in the NW. part of this town. Mag. var. 8° 50′ to 10° 15′ in 1854.

Bath. An area of openings comprising about half of this town in the central and eastern portion, is nearly surrounded by a belt of prairie. Small marshes are scattered through the town. Mag. var. 8° 45′ to 10° 35′ in 1854.

Nunda. This town is also mostly openings, but an area of prairie occurs in secs. 4, 5, 9 and 3, and another lies southwest of Bear lake. Considerable marsh land is embraced within the area of openings. Mag. var. in 1854 10° 5′ to 12° 15′, the latter in sec. 31.

Pickerel. The west half of this township is prairie, and the eastern is devoted to openings with lakes and marshes. Mag. var. 9° 45′ to 11° 50′ in 1854.

Manchester. About one-half of this town is prairie, the

remainder being oak openings. The prairie lies in the northwestern and southern portions. Small marshes occur both in the prairie and openings. Mag. var. 10° to 12° 15′ in 1854.

Hartland. This town is almost entirely composed of prairie, the only timber being about Mule lake, and in the southern portions of secs 34, 35 and 36. There is not much marsh in the town. Mag var. 9° 45′ to 12° 25′ (1854).

Mansfield This town is nearly all prairie, a small patch of oak openings occurring in secs. 3, 10 and 15. The NW. part of the township is rolling and the SE. is level and wet with marshes. Mag. var. 11° 30′ to 13° 40′ (1858).

Alden. This town is all prairie, with scattered small marshes. Mag. var. 11° 27′ to 13° 15′ (1854).

Charleston. This town is all prairie, except a narrow belt of sparce timber about Freeborn lake. Long narrow marshes spread irregularly over the central and eastern portions of the town. In the SE. quarter of sec. 36 there is also a small area of sparse timber. Mag. var. 11° 13′ to 13° (1854).

Freeborn. In this town there is a little sparse timber about the north ends of Freeborn and Spicer lakes, and a little adjoining Spicer lake on the east. There are also some openings in sec. 26, where the arms of the marsh protect the timber from the prairie fires. The rest is of prairie with spreading marshes. Mag. var. (1854) 11° 55′ to 12° 50′.

North and west of Albert Lea is a very broken and rolling surface of sparse timber. This tract consists of bold hills and deep valleys wrought in the common drift of the country. On some of these hills are granitic boulders, but the country generally does not show many boulders. The drift is generally. in this broken tract, a gravelly clay. In some of the street cuts for grading a gravel is found, containing a good deal of limestone.

A great many of the marshes of the county are surrounded with tracts of oak openings, a fact which indicates that the marshes serve as barriers to the prairie fires. Such marshes are really filled with water, and quake with a heavy peat deposit on being trod on. They are very different from those of counties further west, as in Nobles county, which, in the summer, are apt to become dried, and are annually clothed with a growth of coarse grass, which feeds the fires that pass over the country in the fall. As a gene-

ral rule, but little or no grass grows on a good peat marsh.

The contour of the surface of the country is further exemplified by the following elevations obtained from lines run by railroad surveys. They were furnished by Wm. Morin, Esq., of Albert Lea.

Elevations taken from a preliminary survey made in July, 1870, through Freeborn county, Minn., by Wm. Morin:

Commencing on the state line (south), 930 feet east of the ¼ stake, on south side of section 32, T. 101, R. 20: thence north to Shellrock City, on sec. 6, T. 101, R. 20: thence N. 40° W. to Albert Lea, on sec. 8, T. 102, R. 21: thence N. 40° E. to Geneva, on sec. 7, T. 104, R. 20, and thence N. to the Steele county line.

			Above ocean. Feet.
Station No. 1	At point 930 feet E. of ¼ stake, on sec. 32, T. 101, 20.		1,232
"	100		1,241
"	190		1,219
"	199-10—Water in Shellrock river, east bank		1,217
"	200-80— " " " west bank		1,217
"	202		1,232
"	300—Shellrock City (town plat)		1,241
"	494—Summit between Shellrock and Albert Lea.	11 miles	1,[illegible]33
"	654—Albert Lea (town plat)		1,[illegible]63
	Lake Albert Lea		1,[illegible]21
"	1064—Summit at Clark's Grove		1,[illegible]34
	Geneva lake (or Walnut lake)		1,[illegible]34
"	1330—At Steele county line, sec. 5, T. 104, 20		1,226

Elevations obtained from O. D. Brown, Esq., engineer on S. M. R. R.:

	Above the ocean. Feet.
Milwaukee and St. Paul R. R.—Top of rail at Ramsey	1,233
Water in Turtle creek—4 miles west of "	1,204
Oakland station 6 miles " "	1,286
Big marsh 12 miles " "	1,265
Lake Albert Lea—20 miles " "	1,221
Grade at Albert Lea depot	1,240
Jenning's summit 5 miles west of Albert Lea	1,342
Grade at Alden station—10½ miles west of Albert Lea	1,281
" " Wells " 20 " " " "	1,171

The country thus appears to contain some of the highest land in the state. Some of the counties farther west, particularly Nobles, and Mower county on the east, rise from one to two hundred feet higher. There is also a high and rolling tract in the north central portion of the state, covering Otter Tail county, which rises to about the same level, as shown by railroad profiles. The greater portion of the state, however, lies several hundred feet lower than Freeborn county.

Soil and timber.

Throughout the county the soil depends on the nature of the drift combined with the various modifying local circumstances. There is nothing in the county that can properly be designated a "*limestone soil*," or a "*sandstone soil.*" The materials of which it is composed have been transported perhaps several hundred miles, and are so abundantly and universally spread over the underlying rock that they receive no influence from it. The subsoil is a gravelly clay, and in much of the county that also constitutes the surface soil. In low ground this of course is disguised by a wash from the higher ground, causing sometimes a loam and sometimes a tough, fine clay; the latter particularly in those tracts that are subject to inundation by standing water. On an undulating prairie, with a close clay, or clayey subsoil, such low spots are apt to have a black, rich loam or clayey loam, the color being derived from the annual prairie fires that leave charred grass and other vegetation to mingle with the soil. The same takes place on wide tracks of flat prairie. In these there may be but rarely a stone of any kind—indeed that is usually the case—but below the immediate surface, a foot or eighteen inches, a gravelly clay is always met with. This at first doubtless formed the soil, the disintegrating forces of frost, rain and wind, combined with the calcining effects of the prairie fires, having reduced the stones and gravel to powder, leaving a finely pulverized substance for a surface soil. In a rolling tract of country, while the low ground is being filled slowly with the wash from the hills, and furnished with a fine surface soil, the hills are left covered with a coarse and stony surface soil. For that reason a great many boulders are sometimes seen on the tops of drift knolls. Along streams, and about the shores of lakes, the action of the water has carried away the clay of the soil and often eaten into the original drift, letting the stones and boulders tumble down to the bottom of the bank, where they are often very numerous. Along streams they are sometimes again covered with alluvium,—indeed are apt to be--but along the shores of lakes they are kept near the beach line by the action of winter ice. After a lapse of time sufficient, the banks themselves become rounded off, and finally turfed over or covered with trees. These lakes sometimes extend their limits laterally, but slowly become shallower.

This county is furnished with a number of very beautiful

lakes These are generally in the midst of a rolling country, and some of their banks are high.

In the survey of the county the following species of trees and shrubs are noticed growing native:

Burr oak. Quercus macrocarpa *Michx.*
Red oak Quercus rubra *L.* (This species is not satisfactorily identified.)
Aspen. Populus tremuloides *Michx.*
Elm. Ulmus americana (*Pl. clayt.*) *Willd.*
Black cherry. Prunus serotina *Ehr.*
American crab. Pyrus coronaria *L.*
Bitternut. Carya amara *Nutt.*
Black Walnut. Juglans nigra *L.*
Wild plum. Prunus americana *Marsh.*
White ash. Fraximus americana *L.*
Butternut. Juglans cinerea *L.*
Hazlenut. Corylus americana *Walt.*
Frost grape. Vitis cordifolia *Michx.*
Bittersweet. Celastrus scandens *L.*
Smooth sumach. Rhus glabra *L*
Red raspberry. Rubus strigosus *Michx.*
Rose. Rosa blanda *Ait.*
Wolfberry. Symphoricarpus occidentalis *R. Br.*
Bass. Tilia americana *L.*
Prickly ash. Zanthoxylum americanum *Mill.*
Cornel. (Different species.)
Willow. (Different species.)
Gooseberry (prickly). Ribes cynosbati *L.*
Thorn. Crataegus coccinea *L*
Hackberry. Celtis occidentalis *L.*
Sugar maple. Acer saccharinum *Wang.*
Cottonwood. Populus monilifera *Ait.*
Soft maple. Acer rubrum *L.*
Cockspur thorn. Crataegus crus-galli *L.*
Slippery elm. Ulmus fulva *Michx.*
Black ash. Fraximus sambucifolia *Lam.*
High-bush cranberry. Viburnum opulus *L.*
Choke-cherry. Prunus virginiana *L.*
Shagbark hickory. Carya alba *Nutt.* (On M. L. Bullis' land in Moscow township, near the county line.—*A. A. Harwood.*)

Besides the foregoing, the following list embraces trees that are frequently seen in cultivation in Freeborn county:

Spruce.
Red cedar. Juniperus virginiana *L.*
Mountain Ash. Pyrus americana *D. C.*
Balsam poplar. Populus balsamifera *L*, *Var.* candicans.
Lombardy poplar. Populus dilatata *Ait.*
Locust. Robinia pseudacacia *L.* [The locust dies out in Freeborn county.]
Hackmatack. Larix americana *Michx.*
Arbor vitae. Thuja occidentalis *L.*

The geological structure.

There is not a natural exposure of the underlying rock in Freeborn county. Hence the details of its geological structure are wholly unknown. It is only by an examination of outcrops in Mower county and in the adjoining counties of Iowa, together with a knowledge of the general geology of that portion of the state, that anything can be known of the geology of Freeborn county. In the absence of actual outcrops of rock within the county, there are still some evidences of the character of the rock that underlies the county, in the nature and position of the drift materials. There is, besides, a shaft that has struck the Cretaceous in the northwestern portion of the county, in exploration for coal.

Although the drift is heavy it lies in such positions that it shows some changes in the surface of the bed rock. It is a principle pretty well established that any sudden great alteration in the rock from hardness to softness, as from a heavy limestone layer to a layer of erosible shales, or from shales to more enduring sandstone, each stratum having a considerable thickness, is expressed on the drift by changes from a rough and rolling, more or less stony surface to a flat and nearly smooth surface, or *vice versa*. It sometimes happens that the non-outcropping line of superposition of one important formation with another, either above or below, can be traced across a wide tract of drift covered country by following up a series of gravel knolls or ridges that accompany it, or by some similar feature of the topography. Again, the unusual frequency of any kind of rock in the drift at a certain place, especially if it be one not capable of bearing long transportation, is pretty good evidence of the proximity of the parent rock to that locality.

Applying these principles to Freeborn county, we find throughout the county a great many boulders of a hard, white, compact magnesian limestone, that have been extensively burned for quicklime. These attracted the attention of the early settlers, and before the construction of the Southern Minnesota railroad supplied all the lime used in the county. Although these boulders are capable of being transported to a great distance, their great abundance points to the existence of the source of supply in the underlying bed-rock. In the drift also are frequently found pieces of lignite, or Cretaceous coal, which cannot be far transported by glacier agencies. This also indicates the existence of the Cretaceous lignites in Freeborn county. In regard to changes

in the character of the natural surface, we seen a evenly flat and prairie surface in the western tier of towns, and in the southeastern part of the county, and a hilly and gravelly tract of irregular shape in the central portion. There are two ridges or divides, formed superficially of drift, that occur in the central part of the county, one north of Albert Lea, and the other south of it, separated about eleven miles, as shown by a series of elevations from a preliminary R. R. survey by Mr. Wm. Morin, already mentioned. What may be their direction at points further removed from Albert Lea it is not possible to state with certainty, but on one side they seem to trend toward the NW. Indeed there seems to be an NW. and SE. trend to the surface features of Freeborn county generally. Such rough surfaces, and especially the ridges of drift, are more stony and gravelly than the flat portions of the county. They mark the location of great inequalities in the upper surface of the underlying rock, the exact nature of which cannot be known.

In addition to these general indications of the character of the rock of the county, the shaft sunk for coal at Freeborn, reveals the presence of the Cretaceous in that portion of the county, and examinations of the nearest exposures in the neighboring county of Iowa, disclose the Hamilton limestone of the Devonian age. This limestone is exactly like that found so abundantly in the form of boulders in Freeborn county. As the general direction of the drift forces was towards the south, and as the strike of the Hamilton in Iowa, according to Dr. C. A. White (see his map of the geology of Iowa, Final Report, 1870) is toward the N. W., there is abundant reason for concluding that that formation also extends under Freeborn county. The preliminary geological map of the state of Minnesota, published in 1872, indicates Freeborn county almost entirely underlain by the Devonian, the only exception being in the northwestern corner. How much further toward the N. W. these limestone boulders can be traced with equal abundance, the explorations of the survey have not yet revealed. The Devonian does not certainly cross the Minnesota river. Yet in McLeod county, which lies in the line of strike of the Devonian of Iowa and Freeborn county toward the N.W., on the opposite side of the Minnesota river, the same limestone boulders are very abundant, some being so large as to have been reputed rock *in situ*, and quarried as such till exhausted. The northwestern corner of Freeborn county has been regarded as underlain by a limestone of the age of the Nia-

gara, belonging to the Upper Silurian, that formation in the Northwest coming directly below the limestones of the Devonian. That may be correct; but it is certain that there is in the neighborhood of Freeborn an area of the Cretaceous, which must, in that case, overlie the Silurian limestones. This Cretaceous area is believed to extend north and south asross the west end of the county, and to be roughly coincident with the flat and prairie portion in the western part of the county, in which case it always overlaps the Devonian.

Explorations for coal.

In common with many other places in southern Minnesota, Freeborn township, in the northwestern corner of this county, has furnished, from the drift, pieces of Cretaceous lignite that resemble coal. These have, in a number of instances, incited ardent expectations of coal, and led to the outlay of money in explorations. Such pieces are taken out in digging wells. The opinion seems to grow, in a community where such fragments are found, that coal of the Carboniferous age exists in the rocks below. In sinking a drill for an artesian well, at Freeborn village, very general attention was directed to the reported occurrence of this coal in a regular bed, in connection with a "slate rock." This locality was carefully examined, and all the information was gathered bearing on the subject that could be found. The record of the first well drilled is given below, as reported by the gentleman who did the work:

1.	Soil and subsoil, clay	15 feet.
2.	Blue clay	35 feet.
3.	"Conglomerated rock," (had to drill)	2 inches.
4.	Sand and water	5 feet.
5.	Fine clay, tough, hard to drill, with gravel and limestone pebbles	60 feet.
6.	Sand and water	4 inches.
7.	"Slate rock," } Probably Cretaceous.	7 feet.
8.	"Coal," }	5 feet 4 inches
	Total depth	127 feet, 10 inches

This indication of coal induced the drilling of another well, situated 100 feet distant, toward the N. E. In this the record was as follows, given by the same authority:

1.	Soil and subsoil, clay	15 feet.
2.	Blue clay	33 feet.
3.	"Conglomerated rock"	2 inches.
4.	Sand with water, and pieces of coal	12 feet.
	Total depth	60 feet 2 inches

When the drill here had reached the "conglomerated rock" it was supposed to have reached the "slate rock," No. 7 of the previous section. The amount of coal in the sand of No. 4 was also enough to cause it to be taken for No. 8 of the previous section. Hence the boring was stopped; and having thus demonstrated the existence of a coal-bed, to the satisfaction of the proprietors, the enterprise was pushed further in the sinking of a shaft. In sinking this shaft water troubled the workmen so that at 35 feet it had to be abandoned.

Three quarters of a mile north of these drills a shaft was sunk 57 feet, but not finding the coal as expected, according to the developments of the last section above given, the explorers stopped here. In this shaft the overseer reports the same strata passed through in the drift as met with in the first well drilled, but the so called "conglomerated rock" was met at a depth of 45 feet. The sand below the "conglomerated rock" here held no water, but was full of fine pieces of coal. Before sinking the shaft at this place a drill was made to test the strata. These being found "all right" the shaft was begun. In that drill gas was first met. It rose up in the drill hole, and being ignited it flamed up 8 or 10 feet with a roaring sound. The shaft was so near the drill hole that it drew off the gas gradually, allowing the intermixture of more air, thus preventing rapid burning. From this place the exploration was redirected to the first situation, where another shaft was begun. This was in search for the "lower rock," so called, or the "slate rock" supposed to overlie the "coal." Here they went through the same materials, shutting off the water in the five foot sand-bed, and 60 feet of fine clay, when water rose so copiously from the second sand-bed (No. 6 of the first section given) as to compel a cessation of the work. In this shaft were found small pieces of the same coal, all the way. These pieces had sharp corners and fresh surfaces. The total depth here was 106 feet, and the water seems to have been impregnated with the same gas as that which rose in the drill at the point three-fourths of a mile distant. Such water is also found in the well at the hotel in Freeborn. With sugar of lead it does not present the reactions for sulphuretted hydrogen, and the gas is presumed to be carburetted hydrogen.

This account of explorations for coal is but a repetition of what has taken place in numerous instances in Minnesota. The Cretaceous lignites have deceived a great many, and

ısiderable exspense has been needlessly incurred in fruit-s search for good coal. In the early discovery of these nites some exploration and experimentation within the its of the state were justifiable, but after the tests that have eady been made it can pretty confidently be stated that se *lignites are at present of no known economical value.* is, not in ignorance of the fact that they will burn, or that y contain, in some porportion, all the valuable ingredients t characterize coal and carbonaceous shales, but in the ht of the competing prices of other fuels, the cost of min- them, and the comparative inferiority of the lignites mselves. If they were situated in Greenland they would obably be pretty thoroughly explored, and extensively ned, and even there they would have a powerful competitor the oil there in use.*

The drift.

This deposit covers the entire county and conceals the ck from sight. It consists of the usual ingredients, but ries with the general character of the surface. In rolling acts it is very stony and has much more gravel. In flat acts it is clayey. It everywhere contains a great many ulders, and these are shown abundantly along the beaches the numerous lakes of the county. The frequency of lime-one boulders, and their significance, have already been entioned. Thousands of bushels of lime have been made m such loose boulder masses, mainly gathered about the ores of the lakes.

n general the drift in Freeborn county consists of a gla-r hardpan, or unmodified drift. Yet in some places the per portion is of gravel and sand that show all the effects running water in violent currents. The beds here are ique, and subject to sudden transitions from one material another. At Albert Lea the following section was ob-ved. It occurs just west of the center of town. It cov- eight feet perpendicular, and eight feet E. and W.

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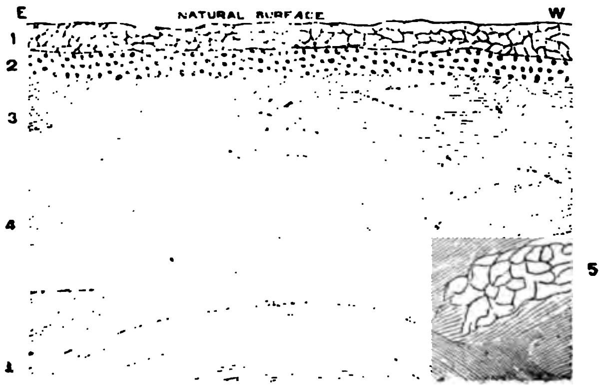
e the second annual report, pp. 187 and 201.

Section in the drift at Albert Lea.



Explanations.

1. Earth and soil, gravelly below.......................... **20 inches.**
2. Gravel, unstratified, with considerable limestone....... **6 inches.**
3. Stratified gravel.... .... **18 inches.**
4. Regular strata of coarse gravel......................... **2 feet.**
5. Unstratified............. ....
6. Fine sand, seen................................. ...... **2 feet.**

In a gravel bank at Albert Lea, according to Mr. William Morin, the jawbone of a mastodon was found, a number of years ago. It was sent to St. Paul, and is supposed to be preserved.

The average thickness of the drift in Freeborn county would not vary much probably from 100 feet.

In the survey of the county considerable attention was paid to the phenomena of common wells, with a view to learn the nature and thickness of this deposit, and the following list is the result of notes made :

Wells of Freeborn county.

Good water is generally found throughout the county, in the drift, at depths less than 80 feet; but some deep wells that occur within the Cretaceous belt, in the western part of the county, are spoiled by carburetted hydrogen. This must rise from carbonaceous shales in the Cretaceous, and indicates the extent of that formation. Much of the information contained in the following tabulated list of wells was obtained by W. A. Higgins, well borer, of Albert Lea:

ne.	Location.	Depth. Feet.	Kind of Water.	Remarks.
......	Sec. 20, Albert Lea.	28	Good.	One-half bu. of coal at 26 ft.
......	Freeborn.	47	Carburetted	Pieces of coal in blue clay,
ick...	"	48	Soft.	44 ft. of water. [26 ft. water
......	½ m. w. of Freeb'n.	30	Good.	Found pieces of coal.
......	" "	42	"	" " "
1.....	1 m. nw. of Freeb'n.	50	Carburetted	" " "
.....	Sec. 13, Freeborn.	90	"	Water stands 5ft. from top.
......	Byron, Waseca.	94	Soft.	[stones and gravel.
......	6 ms. nw. Freeborn.	98	Good.	Artesian; at first bringing
Ir....	2 ms. nw. Freeborn.	61	Carburetted	[clay
.....	Alden.	37	"	Found pieces of coal in
......	"	50	Good.	" " " "
r.....	"	50	"	" " " "
. ....	6 ms. nw. Freeborn.	96	Carburetted	Artesian.
k.....	2 ms ne. Alden.	48	"	Nearly artesian.
.. ...	Nw. cor. Freeborn.	125		Bore for coal.
......	Trenton.	142		" " " lost tools.
ck...	Freeborn.	35	Carburetted	Blue clay, water in sand &
....	Geneva.	20	Good.	Water in q'ksand. [gravel.
ley..	"	12	Soft.	Water in quicksand.
.....	"	12	"	" " "
in...	"	12	"	" " "
......	Albert Lea.	72	Good.	Struck gravel below the
ard..	"	38	"	In gravel. [blue clay.
......	"	52	"	Small bed of gravel in blue
......	"	25	"	In gravel. [clay.
......	"	72	"	In gravel below blue clay.
......	"	85	Not good.	Struck black clay, no
				sticks nor grit. [clay.
......	"	30	Good.	In very fine blue sandy
......	"	28	"	"Yellow clay" all the way.
......	"	72	"	Yel.& blue cly. then gravel
ch ...	Sec. 4. Albert Lea.	42	"	Gravel and sand, water in
......	Albert Lea.	34	"	" " " [quicksand.
......	Sec. 28, Albert Lea.	28	"	Water in gravel. [on rock.
......	Sec 29, "	65	No water.	Grav'ly cl'y. fine sandy cly
......	Sec. 29, "	28	Good.	Water in green sand.
ge...	Sec. 8, "	28	"	" " "
......	Albert Lea.	32	"	Gravel and sand, then q'k-
......	"	65	"	" " [sand.
......	Alden.	44	"	In gravel.
1.....	Albert Lea.	80	Not good.	Drift clay, water in gravel
scott		80	"	"Tastes like kerosene."
.....	Twin Lakes.	75	"	Clay only.
	Alden.	40	"	
......	Sec. 29. Albert Lea.	30	"	Lump of coal at 27 feet.

: wells at Albert Lea a muck is struck, and such rd a water that is unfit for use. This muck is :o contain sticks, and is about 38 or 40 feet below :e. It may indicate a former bed of the river, or acial marsh, as Mr. James Geikie has explained in (See "The Great Ice-Age.") It is by some *sh*, and seems not to uniformly hold sticks and it to be rather a fine sand of a dark color. The ›rs call it quicksand. This indicates that it is either 'retaceous black clay, arenaceous, or Cretaceous dé- Wedge, of Albert Lea, thinks the site of the city covered by a lake, and that this *slush* was its sedi- l that the overlying gravel, which is about 38 feet ; since been thrown on to it by a later force, per- currents. There is no doubt that the overlying

gravel was thus deposited, those currents being derived from the ice of a retiring glacier.

Wells at Geneva are generally not over 20 feet in depth They also pass through a gravel that overlies a quicksand. This village it situated with reference to Geneva lake as Albert Lea is with reference to Albert Lea lake, both being at the northern extremities of those lakes. The phenomena of wells at the two places are noticeably similar, and in the same way different from the usual phenomena of wells throughout the county.

At Albert Lea.

Gravel, about 30 feet.
Quicksand, with water, sometimes black and mucky.

At Geneva.

Gravel, 12 to 15 feet.
Quicksand, with water.

It would seem that the history of the drift at Albert Lea was repeated at Geneva. These villages being both situated at the northern end of lake basins, are probably located where preglacial lakes existed. On all sides, both about Albert Lea and Geneva, the usual drift clay, hard and blue, is met in wells, and has a thickness of about 100 feet.

Material resources.

In addition to the soil, Freeborn county has very little to depend on as a source of material prosperity. As already stated, there is not a single exposure of the bed-rock in the county. All building stone and quicklime have to be imported. The former comes by the Southern Minnesota R. R. from Lanesboro and Fountain, in Fillmore county, though it is very likely that the Shakopee stone from Mankato will also soon be introduced. The latter comes from Iowa, largely, (Mason City and Mitchell), and from the kilns at Mankato and Shakopee. Some building stone is also introduced into the eastern part of the county from the Cretaceous quarries at Austin.

Lime.—At Twin Lake three or four thousand bushels of lime have been burned by Mr. Carter from boulders picked up round the lake shores. This lime sold for 75 cents per bushel. It was a very fine lime, and purely white. The construction

` to his profits, as the Shakopee lime
nd sold cheaper. The boulders
of the same kind as those that
nty. They are fine, close-
.eathered surfaces, and of a
.ractured surfaces. They very
.ular or rougher texture, like a mag-
ough this grain is intermixed with the
.ey hold but few fossils. There are a few
.a shells, and by some effort a globular mass of
.avositoid coral was obtained.

.ides the above, which are distuinguished as "white
stone," there are also a few bluish-green limestone boul-
s. One of these, which now lies near Twin Lake, is
it 7 feet long, by 5 or 6 feet broad, its thickness being at
t 2½ feet. It has been blasted into smaller pieces for
cing quicklime, but nearly all of it yet lies in its old bed,
fragments being too large to be moved. This stone is
very close grained. It is heavier than the other and
e evidently crystalline. It holds small particles of pyr-
. It is not porous, nor apparently bedded. On its
er surface it looks like a weathered diorite, and it would
taken, at a glance, for a boulder of that kind. It is said
make a very fine lime. Several hundred bushels of lime
re formerly burned at Geneva.

Brick.—At Albert Lea the following persons make brick: George Broughton, Wm. Cook, (G. C. Dillingham,) Hub-
ll Manly, (one and a half miles N of Albert Lea; has
de none in four years.) These all make what is known
"slop brick," i. e., they handle and dry them after mix-
; in water, without the use of sand. The latter method
th sand) is much quicker and pleasanter, but in the use
the brick there is not much choice between the methods.
Boughton's the brick are red. The clay used, which is
out five feet below the surface, is fine and of a yellowish
y color. It is underlain by gravel. The clay itself
ally passes into a sand that looks like "the bluff." At
er places it is a common, fine clay-loam, with a few gravel-
nes. There is but little deleterious to the brick in the
y, although some of the brick are, on fractured surfaces,
newhat spotted with poor mixing, and with masses of
at appear like concretions. The clay itself is apparently
ssive, but it is really indistinctly bedded, rarely showing
horizontal or oblique, thin layer of yellow sand. Mr.
ughton sells brick at ten or twelve dollars per thousand.

His yard has only been running the past summer, but has turned out 200,000. They have been used in Albert Lea, aud by the farmers around. Oak wood costs from five to six dollars per cord.

The yard of Mr. Cook also furnishes red brick. He uses the same stratum of fine clay overlain by the same yellowish sandy clay or loam. The clay here shows to better advantage and is plainly bedded. It contains sticks, the largest observed being a little over half an inch in diameter. These sticks are plainly endogenous in cellular structure, but have a bark. They are not oxydized so as to be brittle, but are flexible still, with small branches like rootlets hanging to them. It is uncertain whether they belong to the deposit, or are the roots of vegetation that grew on the surface since the drift. There are no boulders of any size in the drift just here; but a few granitoid gravel-stones. The aspect generally indicates that this clay has a local character largely, but no outcropping beds can be found in the neighborhood. Mr. Cook has made this year (1874) 250,000 brick. The yard has been running five years. Brick here sell for $1.30 per hundred as they come from the kiln, or $10.25 per thousand. Hard brick from the arch sell at $1.50 per hundred. The brick here seem to show a little more lime, but they are well made and well burned.

Brick were formerly made at Geneva, and at a point about 2½ miles east of that place. At Geneva the clay was taken from the bank of Allen creek, about 18 inches below the surface. It was a drift clay, with small pebbles. That used 2½ miles east of Geneva was of the same kind. In both places sand had to be mixed with the clay. About Geneva sand is abundant, taken from the gravel and sand knolls, and from the banks of the creek.

Peat.—In Freeborn county there is an abundance of peat. The most of the marshes, of which some are large, are peat-bearing. In this respect the county differs very remarkably from those in the western portion of the same tier of counties which were specially examined for peat, in the season of 1873, and which, being entirely destitute of native trees, are most in need of peat for domestic fuel.

The peat of the county is generally formed entirely of herbaceous plants, though the marshes are often in the midst of oak-openings. The peat-moss constitutes by far the larger portion. There is no observed difference in peat-producing qualities between the marshes of the prairie districts and those of the more rolling woodland tracts of the country.

At Alden village, in the midst of the open prairie, the peat of a large marsh rose to the surface and floated, when, for certain purposes, the marsh was flooded. The water now stands ten feet deep below the floating peat, which is about three feet thick.

At Freeborn peat is now being taken out on John Scovill's land. Here it is eight feet thick, two rods from the edge, and it is probably much thicker toward the center of the marsh. That below the surface of the water now standing in the drain is too pulpy to shovel out; and after being dipped out and dried on boards, it is cut into blocks and hauled to town. That above the water is more fibrous, and can be taken out with a spade in convenient blocks. Yet the level of the water varies, and that datum is not constant. It appears as if there was here a stratum of more fibrous peat that separates from the lower, about 20 inches thick, and floats above it at certain times. In the peat at this place a sound elk horn was taken out at the depth of 6 feet.

There is a large peat marsh in sec. 11, Hayward, owned by non-residents.

REPORT ON THE GEOLOGY O] MOWER COUNTY.

Situation and area.

This county borders on the state of Iowa. It is bounde west by Freeborn county, north by Dodge and Olmste and east by Fillmore. It has Mitchell county on the sout in Iowa. Its shape is very nearly that of a rectangle, (towns east and west, and 4 towns north and south), but lacks the northern line of sections in the northeast, acro two towns. These sections were set off to Olmsted coun when Austin was made the county seat. It has, therefor about 708 square miles, or more exactly, 455,204.81 acre according to the records of the State land office.

Natural drainage.

The Cedar river crosses this county from north to sou through the western line of towns, its point of exit bei exactly south from its point of entrance. Its chief tribu ries from the east are Dobbin's creek, Rose creek, Ot creek and Robert's creek. From the west it receives chard creek and Turtle creek. Thus the whole of western half of the county is drained into the Mississip through Iowa. The southeastern portion, also, is drai toward the south, through the sources of the Little Ced the Wapsipinicon and the Upper Iowa rivers. The nor eastern portion of the county is drained by the head wat of the Root river toward the north and east. This ri flows eastward through Fillmore and Houston counties, i the Mississippi near La Crosse. The divide between strea running north and those running south crosses Mo county from SE. to NW. nearly through the center,

includes some of the highest land in that portion of the state. The highest point in the county, on the Southern Minnesota R. R., is in sec. 13, T. 103, R. 16 W., and that is 738 feet above Mississippi at Grand Crossing, or 1352 feet above tide water.

These streams are all small, and some of them become nearly dry during the summer. Some of them furnish water power at a number of places. This has been improved on the Upper Iowa at Le Roy, and on the Cedar at Ramsey, Austin, and at several places below Austin, in the construction of flouring mills.

Surface features.

The county is distinctively one of prairie, yet has a considerable timber along the streams. This is particularly the case along the Upper Iowa in the southeastern part of the county, along the eastern tributaries of the Root in Frankford, and along the Cedar crossing the whole width of the county. There is is also an important tract of timber in Nevada township. The highest portions of the county are entirely destitute of trees. They consist of a wide expanse of undulating prairie. The southern towns of Lyle, Nevada and Adams may be characterized as flat. The same is true of the most of the supposed Cretaceous area. The summit of the principal NE. and SE. watershed is formed by the Lower Devonian, with the strike of which it substantially corresponds. Toward the east from this summit the valleys of the streams running in that direction have been deeply cut out, yet not revealing any rock. They are wide, and their natural scenery is often very fine, as the view of the low expanse, wooded more or less, first appears before the traveler. The western portion of the county is considerably below the central and eastern. This is owing to the valley of the Cedar, the effect of which is felt over a wide belt, in depressing the general level. The following points of elevation above the ocean are derived from the profile of the Southern Minnesota R. R. by O. D. Brown, engineer:

Grand Meadow, (sec. 14, T. 103, R. 15)	1325 feet.
Sec. 13, T. 103, R. 16	1402 feet.
Ramsey, (grade of the Milwaukee & St. Paul R. R.)	1233 feet.*
Hayward	1240 feet.

*In the report for 1872 this crossing is given at 593 feet above the Mississippi river at La Crosse, the datum line of the S. M. R. R. on the authority of chief engineer H. W. Holley. Adding 614 feet makes 1207 feet for its hight above the ocean.

The following were derived from the Milwauke & St. Paul R. R., through ——— Angst, chief engineer:

Madison	1127 feet.
Ramsey	1093 feet.
Lyle	1075 feet.

The following minutes, touching the surface features, are based on an examination of the township plats of the government surveys, on record in the land office. The county was surveyed in 1853. There is not a lake of any importance in the county, and but few marshes.

Le Roy. (101,14)—East half.

The Upper Iowa river crosses diagonally the southern portion of this town, and introduces a belt of undulating and more or less timbered land, about two miles in width. Some of the thickets are very dense, but generally the timber is scattering. The remainder of the town is prairie, with a large slough covering portions of secs. 5 and 8. There is a "second bottoms" noted in sec. 18, and John Priest's house in sec. 36. Magnetic variation 9° 12′ to 10°.

Bennington. (102,14.)

In the center of this town is one of the sources of the Root river, a Y-shaped slough, with an outlet toward the east. The whole town is prairie. Mag. var. 8° 15′ to 12° 30′, the former in sec. 6, the latter in sec. 3.

Frankford. (103,14.)

This town is about equally divided between prairie and openings, the former being the SW. portion and the latter the NE. portion. The timber is generally small, and often scattering. There is a marsh in sec. 9, and settlement was begun in NE. corner of sec. 1. Mr. L. Patchin, of Frankford, was one of the first settlers. Mag. var. 7° (in sec. 7) to 12° 15′ (in sec. 36.)

Racine. (104,14.)

There is a belt of openings, and undulating land along the southern line of this town, caused by the tributaries of the Root river, and other areas of sparse timber and brush in

cs. 10, 8 and 7, but the greater portion is of prairie. It ntains but little marsh. Var. 6° 57' to 11° 15'. Mr. J. cQuillan was the earliest settler in Racine. The same ar Mr. L. Patching settled at Frankford and laid out the llage.

Le Roy. (101.15)—West half.

This town consists almost entirely of prairie. The Up- r Iowa river in the eastern portion introduces some diver- y of surface, and some timber. There is also a small area similar land in the NW. corner of the town. The head- aters of the Wapsipinicon are in sec. 32, and drain a long, rrow marsh, that extends two miles further north. The ost of this town is prairie land. Mag. var. 8° 34' to 9° '.

Clayton. (102,15)

This is a high prairie town, the drainage from it being to e SW. SE., and NE. Mag. var. 7° 39' to 9° 7'.

Grand Meadow. (103.15.)

This township is all prairie. There is a slough with some anding water in secs. 17 and 20. Several of the high ibutaries of Root river drain the eastern portion, introduc- g but little diversity of surface. Mag. var. 7° 35. to 8° '.

Pleasant Valley. (104.15.)

Except very small areas in the NE. and NW. corners of is town, it is entirely taken up with excellent prairie land. ose exceptions are small tracts of undulating and brushy, sparsely timbered land, along the tributaries of the rth fork of Root river. Var. 7° 50' to 8° 55'.

Adams. (101.16.)

Through the central and northeastern portions of this town n the headwaters of one of the tributaries of the Cedar ver, causing a belt of diversified country, widening to the rth, and spreading into the northeastern part of the town. the east and west of this belt is prairie land. Mag. var. 43' to 10° 5'.

In the northwestern portion of this town Rose creek introduces the usual variety of surface attending drainage val leys. Other areas of the same are in secs. 34 and 36. The rest is prairie. Mag. var. 7° 53′ to 9° 18′.

Dexter. (103,16.)

The southern part of this town is diversified by Rose creek. otherwise it is a prairie with drainage to N. and W. Var. 7° 25′ to 8° 30′.

Sargent. (104,16.)

This is of prairie, except in the eastern portion, where the valley of one of the upper tributaries of Root river causes an undulating belt with some timber. This belt runs NE., and is about a mile wide. Var. 7° 47′ to 8° 55′.

Nevada. (101,17.)

This town is mainly prairie, perhaps one-fifth of the whole area, situated in the southweastern quarter being openings and more undulating. Var. 7° 32′ to 9° 45′.

Windom. (102,17.)

The southern and central portions of this town are prairie —a wide strip along the west side, and a narrow one along the eastern, being more wooded. Rose creek crosses it from NE. to SW. It contains no lakes nor marshes. Var. 7° 24′ to 10° 6′.

Redrock. (103,17.)

The eastern half of this town is prairie. the western half openings. with small timber and brush. Mag. var. 7° 9′ to 8° 59′.

Waltham. (104,17.)

This town is mainly prairie, the only exception being about the streams in the SW. quarter. Mag. var. 7° 35′ to 8° 35′.

Lyle. (101,18.)

This township, being crossed by the Cedar, enjoys all the variety of soil and surface, as well as the timber which uniformly accompany the principal drainage courses. A belt of timber along the east side of the Cedar crosses the center of the town from north to south about a mile in width. The prairie on the west side runs to the very river. A wet meadow, or slough, occurs in sections 8 and 17, and another in sec. 2. Mag. var. 6° 57′ to 9° 54′.

Austin. (102,18.)

The western half of this town is prairie reaching up to the river. The eastern half is more wooded and broken. There is also a patch of prairie in the SE. corner south of Rose creek. Dobbin and Nichols were early settlers in the SE. corner. According to Mr. Patchin, of Frankford, Leveridge, was the earliest settler at Austin. Mag. var. 6° 57′ to 9° 42′.

Lansing. (103,18.)

There is a small area of prairie in the northern part of this town, but the most of it when surveyed was taken up with openings with scattered trees and brush. In the SW. quarter of the town is a long marsh drained into the Cedar. It is about three miles in length and a quarter of a mile wide running SE. Mag. var. 7° 9′ to 8° 40′.

Udolpho. (104,18.)

A belt of undulating, and more or less timbered, land crosses this town from N. to S. accompanying the east shore of the Cedar river. It is about two miles in width, increasing to four miles in the north. A small area of similar land is found covering portions of sections 30, 31 and 32. An important marsh also occurs in sections 27 and 34. Var. 7° 35′ to 9° 26′.

Soil and timber.

The soil of Mower county is everywhere dependent on the nature of the drift. The underlying rock has only affected it so far as it may have mingled with the general mass. It

is hence primarily a gravelly clay, that being the character of the subsoil throughout the county. This gravelly clay, however, is not now prominently displayed as the immediate soil of the surface. Indeed the farmer in plowing rarely penetrates to it. It lies below a rich loam usually, at depths varying from zero to two or three feet, or even more. The surface itself, which has resulted from it through the agency of the forces of the atmosphere and of vegetation, is of dark color, and in general may be designated a clayey loam or a sandy loam, depending on the nature and completeness of the local drainage. In low grounds this loam is thick and of a dark color. It is also apt to be more clayey in low ground than it is on the hillsides or slopes adjoining; and on high hills or steep slopes it is thin or wanting, the wash of the surface having carried it into the valleys. Along streams it often consists of an arenaceous loam, variously mingled with the detritus of the flood plain.

The soil of the county is everywhere characterized by the strength and fertility that the drift soils of the northwest are noted for. They are the most reliable soils for all the purposes of the farmer that are known. The states that are regularly and deeply buried in drift deposits are known as the best farming states of the Union. Certain rock-soils, endowed with unusual special qualities, may excel in the production of certain crops, especially in favorable seasons, but for general tillage they cannot compete with the homogeneous drift soils, through which are disseminated the good qualities of the various rocks concerned in their production, in the proportion that make stability and diversity equally certain.

In the examination of the county the native varieties of trees and shrubs were noted, and the following list comprises the species that were seen. In respect to the trees it is probably nearly complete for the county, but there are, doubtless, other species of shrubs:

Trees and shrubs of Mower county.

Burr oak. Quercus marcrocarpa *Michx.*
Red oak. Quercus rubra *L.* (Not fully identified.)
Aspen. Populus tremuloides *Michx.*
American elm. Ulmus americana (*Pl. Clayt.*) *Wild.*
Different species of willow. Salix.
Hazelnut. Corylus americana *Walt.*
Sumac. Rhus glabra *L.*
Ironwood. Ostrya virginica *Wild.*
Bass. Tilia americana *L.*

Elder. Sambucus canadensis *L.*
Wolfberry. Symphoricarpus occidentalis *R. Br.*
Prickly gooseberry. Ribes cynosbati *L.*
Cornel. Cornus (sp. ?).
American crab. Pyrus coronaria *L.*
Red osier dogwood. Cornus stolonifera *Michx.*
Alder. Alnus incana *Willd.*
Cottonwood. Populus monilifera *Ait.*
Thornapple. Crataegus coccinea.
Wild plum. Prunus americana *Marsh.*
Black cherry. Prunus serotina *Ehr.*
Frost grape. Vitis cordifolia *Michx.*
Bittersweet. Celastrus scandens *L.*
Black currant. Ribes floridum *L.*
Wild rose. Rosa blanda *Ait*
Cockspur thorn. Crataegus crus-galli *L.*
White ash. Fraxinus americana *L.*
Shag-bark hickory. Carya alba *Nutt.*
[At Lansing, and in the valley of the Cedar, one foot in diameter.]
Sugar maple. Acer saccharinum *Wang.*
Bitternut. Carya amara *Nutt.*
Butternut. Juglans cinerea *L.*
White pine. Pinus strobus *L.*
[Along the rocky banks of the streams in the eastern part of the county.]
Slippery elm. Ulmus fulva *Michx.*
Black ash. Fraxinus sambucifolia *Lam.*
High bush cranberry. Viburnum opulus *L.*
High blackberry. Rubus villosus *Ait.*
Cedar. Juniperus virginiana *L.*

The geological structure.

Of the older rocks the lower portion of the Devonian and the upper portion of the Silurian are found within the county dipping towards the southwest. The western portion of the county is known to be immediately underlain by the lower Cretaceous, without ascertainable eastern limits. The accompanying geological map of the county exhibits the areas of these formations as nearly as can be judged by the data known. The rock is nearly every where hid by the drift and for that reason the actual positions of the boundaries are unknown. It is quite possible, indeed probable, that the Cretaceous area extends further east, with a broken and very tortuous eastern boundary. It occurs in counties further east. In regard to the separation between the limestones of the lower Devonian and the Upper Silurian, none has yet been discovered. It is simply known that a vast limestone formation, the upper part of which lies under Freeborn county next on the west, extends also under Mower, and appears conspicuously along the banks of the streams in the eastern portion. No characteristic fossils have yet

been seen in it in Mower county, but those that characterize the Hamilton were seen in it near Northwood in Iowa. The limestone seen at Le Roy is lithologically different from that which occurs at Frankford and resembles the Hamilton seen at Northwood. While lithological distinctions are not reliable always, especially after long intervals, yet at present this is the only reason known, so far as Mower county is concerned for separating that at Frankford from that at Le Roy. In Ohio and Illinois there is an arenaceous formation (the Oriskany) between the Devonian limestones and the Silurian, and it distinctly marks that horizon. While in the lower Devonian some arenaceous layers have been observed in Iowa, the Oriskany has not been identified there, and probably it cannot be depended on in Minnesota to mark the separation between the Upper Silurian and the Devonian. In the absence of good exposures of these limestones in the county, it is only possible to lay down approximately the boundary line between them, and that is all that has been attempted on the accompanying map.

The Cretaceous.

The principal exposures of the Cretaceous are found in the valley of the Cedar, at Austin, and from there to the state line. The quarry of Simon Anderson, at Austin, is in the left bank of the Cedar, and exposes about 20 feet of the bedding. Much of the stone is broken and disturbed, and lies in fine clay which seems to have been jammed into all the cracks and other openings in the rock. The beds here show sudden, broken-down places, in which this clay is deposited instead, the rock being wanting for three or four feet horizontally. The stone is much more entire, and uniform in all its characters at greater depths, some slabs five and six feet long, by three feet wide, and three or four inches thick being taken out. These have a very even, fine grain, and a handsome blue color. This stone is in its natural color, light blue, and that color shows on most of the quarried blocks about the heart of the bedding; and on deep quarrying it would doubtless show only a blue color. Yet the stone seen about the city is very generally of a buff color, to the depth of half an inch to three inches, depending on the amount of weathering and oxydation. The thinner beds are altogether changed to that color. The presence of occasional concretionary iron and mud balls causes a rusty stain of a yellow color over the surface of many of the slabs.

hese concretionary balls fall out, or dissolve out, when in the ater, and leave cavities which become larger still. Besides ese, which are not common in the compact portion of the one, but are oftenest seen among its thin beds, there are so cavities disclosed by the fracture of the homogeneous ick beds. These are sometimes perfectly empty, but often ntain loose, friable matter, easily picked out, but not ffering in color or grain from the mass of the rock. At her times such cavities, revealed on the fracture of the one are lined with a perfect coating of drusy crystals which e white, and as hard as quartz, though sometimes covered th iron-rust, so as to present a red or black exterior. The xture of the stone itself is usually close, and the grain is mogeneous. Some large slabs and blocks are sawn for ses to tombstones, and worked down to a very smooth rface. It is more safely sawn to any desired dimension at cut or broken, since it fractures treacherously; yet it not in the least crystalline. Its aspect at a distance is at of a fine-grained sandstone; yet it contains no apparent it. It is so soft that it can be cut without difficulty, ap- aring much like an unusually indurated blue shale, but it rdens in use and becomes a very enduring and useful ma- rial for building. It contains, but very sparingly, a few olluscous fossils, too much absorbed to be identified, though e has the general form of a *Gryphaea*. This description the stone applies equally well for the stone taken out at her quarries further down the valley, as mentioned below.

In the vicinity of Mr. Alderson's quarry, perhaps fifty ds distant, and about 14 feet higher, this stone was struck making an excavation for the erection of a brewery. It ere rose within two or three feet of the surface. The beds ere thin, broken, and of a buff color. Enough stone was ere obtained, in the excavation of a small vault, for the ma- onry appertaining to the brewery. The rock was here verlain by the following section of clays.

o. 1.	Black sandy loam and soil	2 to 4 feet.
o. 2.	Band of red and variegated compact clay	6 in. to 4 feet.
o. 3.	Yellow ocherous band of clay.	6 in. to 4 feet.

The superposition of these bands of clay is not so regular s indicated by the foregoing section: occasionally No. 3 is roken through or is wanting, and No. 2 lies on the rock, or asses down into its crevices. Yet No. 3 is generally the rst over the rock. They vary in thickness and swell out shapeless masses of hard clay. Such hard masses are

seen sometimes to embrace bits of angular earthy rock, much like ochre, varying in color from a dark, burnt-umber color to a lighter shade, even to buff, and appearing, when of a lighter color, much like the mass of No. 3. They can be scratched easily with a knife, and however black they may be they give a red hematite streak. When they are faded the streak also fades into a brown or yellowish brown like limonite. Intermingled very irregularly with No. 2 and sometimes also with No. 3 are masses of greenish clay which has in every other respect the same outward characters as No. 2. There are here also large crystalline, detached masses of apparently a silicious limestone which is very hard and close-grained. In some cases, however, this varies to a porus and nearly white limestone that appears to be very pure.*

At Austin angiospermous leaves were obtained from this stone in the digging of a well by Mr. L. G. Basford. After passing through soil and loam three or four feet, and clay about 20 feet, the rock was struck and penetrated by removing the upper layers, a thickness of about eight feet. Two species of fossil leaves were found in the layers thus entered. One appears like *Ficus primordialis* Hr., as figured in "*Les phyllites Cretacees du Nebraska par M. M. les prof. J. Capelini et O. Heer*," and the other is, according to Dr. J. S. Newberry, to whom a photographic copy was submitted, probably a species of *Sequoia*, a gymnosperm of the pine family known as "redwood."

At the mill of J. Gregson, about two miles below Austin, a great deal of stone has formerly been taken out, but now the quarries of that neighborhood are nearly all flooded by the water of the dam. The chief quarry was just above the present site of the mill and near the dam on the left side, though just below the dam the rock shows on both sides and has also been wrought. At this point Rosenberry and Miner have a quarry on the right bank, and a perpendicular bluff of the beds occurs near the roadside, below the mill on the left bank. The exposed section at Rosenberry and Miner's is as follows, in descending order:

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*In connection with this description of limestone masses, it is interesting to note the occurrence at St. Charles, Winona county, of hard siliceous limestone masses on the surface of the ground, appearing very much like those embraced in this clay.

The reader is also referred to the *Geological report on the exploration of the Black hills under Gen. G. A. Custer, 1874*, for further information on the distribution of foreign limestone masses in Dakota.

No 1.	Black loamy soil	7 to 8 feet
No. 2.	Loose fragments of the underlying beds and clay mixed	3 feet
No. 3.	Heavy stone like that described at Austin, clay filling the open planes and joints	10 to 12 feet
No. 4.	Rusty bituminous films	¼ to 1 inch
	[On the authority of the owners of this quarry to this section may be added the following.]	
No. 5.	Limestone, filled with shells, blue, contains flint, makes lime, penetrated	2 feet

The bedding of No. 3 is here broken in a manner similar to that of Alderson's quarry at Austin. The corners and angles of the beds are replaced by clay and the color of the stone is changed from blue to buff or drab, to the depth of about two inches.

Some years ago the rock was worked by Dr. Barns, of Austin, about half a mile above Gregson's mill. This quarry is now almost entirely flooded by the dam. The abutments of the upper bridge, at Austin, came from this quarry, in part. Judge Ormanzo Allen owned a quarry still above Barns' that was also considerably flooded by the same means. The quarry most worked was just above the mill, owned by M. J. Woodson. It is now entirely under water. Stone is still taken out, however, all along, both above and below Gregson's. The beds at Gregson's show very nearly the same characters as at Austin. The descent of the stream is over about fourteen feet of rock, the layers of which are sometimes two feet or more in thickess, or massive, much like an indurated shale. In weathering, these thick beds are checked by planes running mainly horizontal, instead of perpendicular or diagonal. Although mainly horizontal these planes are apt to unite after a few feet, splitting up the heaviest beds into wedging, lenticular masses. Some parts are here plainly calcareous, affording traces of fossil remains that have the appearance of Brachiopoda. These portions are porous as if by the absorption of fossils.

Mr. M. J. Woodson now works a quarry about ¼ mile above Gregson's mill, some distance from the river, pumping by windmill the water out of a slough in which the beds are exposed. A small creek passes through here, and this slough seems to be an expansion of the valley, retarding the water. The rock is here entirely below the water, and is nearly all blue, and in that respect appears well.

At the mouth of Rose creek about the same thickness of the same kind of stone can be seen in the bed and banks of the creek. A fine exposure is owned by J. D. Wooodard in

the right bank of Rose creek near the crossing of the road from Austin to Officer's mill, perhaps a mile above its union with the Cedar. It is again seen above Officer's on the land of Col. Lewis, on the east bank

At W. H. Officer's mill, the left bank of the river shows about 20 feet of bedding. This is one mile below Rose creek. South of this mill rock of the same kind is seen at a number of places before reaching the state line. At two miles below Officer's it is quarried on R. B. Foster's land; and on Mrs. John Niles', three-fourths of a mile below Foster's, on the west side of the river. Just below the state line is Alderson's mill, where it is again exposed. At officer's, the water power is 8 feet. It is 13 feet at Gregson's and 10 feet at Austin. Between Austin and Lyle the country is apparently a perfectly level prairie, and is doubtless closely underlain with the same rock as at Austin.

Two miles east of Officer's mill a farmer struck the same rock in two separate wells on his farm, in one at the depth of three feet and in the other at eleven.

Dobbin's creek, which joins the Cedar at Austin from the NE., furnishes a water-power of 14 feet by dam, where a mill is erected. A quarry in the left bank of this creek shows the same rock as already described at Austin in the Cedar. The bluffs of the creek just below the mill are about 30 feet, and show about 20 feet of rock. The beds are in every place greatly broken, and in some cases displaced. The rock is parted into blocks of varying size, according to the thickness of the layers, the uppermost being finest. Throughout, the partings, and all the interstices are closely filled with a greenish clay, making the whole a close and almost impervious mass. It has very much the aspect of the Cretaceous on the Silurian, as described at Mankato, (see the second annual report) except that the small cracks and openings are here all densely filled with the clay. The clay also very rarely has any distinct bedding, but seems rather to have been jammed in to fill the vacancies. Besides the greenish clay which often varies in color to a red or a buff, there is also considerable white, clean sand, lodged in these cavities in the rock. This pertains to no particular horizon, and shows no definite arrangement. It is disposed everywhere, just like the clay, occurring from the top to the bottom of the bluff—though perhaps more abundant near the bottom.

These two deposits—the clay and the white sand—are doubtless the result of destructive forces upon other portions

of the Cretaceous. There is presumptive evidence, in their being here irregularly mingled with a series of beds that lie nearly *in situ*, that they are derived from some *overlying* members of the Cretaceous. That evidence would be more reliable if the general dip of the Cretaceous were toward the north or northwest, thus throwing the beds of the quarry deeper below the surface in those directions and rendering them less susceptible of such disruption as would expose the underlying members to the glacial forces. That is naturally the first inference on beholding the face of the bluff. On the contrary the actual dip of the Cretaceous, if it have any at all, would be in general toward the south or southwest at this place, and the lower members are thus brought nearer the surface and within the transporting agency of the glacial forces at points toward the north. Thus this clay and sand may have been brought, by the action of ice, in the glacial epoch, from the north or northwest and deposited on the top of an overlying rock, in the same manner as granitic boulders are brought from a granitic region toward the north and are spread by the agency of ice, over the Silurian or Devonian, or even over the Cretaceous, that overlie, by hundreds of feet, the granitic beds from which they are derived. This clay and sand, however, are so fragile that they would soon lose their identity in being carried by the mixing power of a glacier, and cannot have been far transported. Indeed the area over which the beds of the rock with which they are mingled are known to extend unbroken, without perceptible dip in any direction, is quite as great as they could be carried by glacial action and deposited in distinct and characteristic homogeneity. There is hence a strong probability that the rock from which they are derived occupies a higher geological horizon than that among the broken beds in which they appear. This white sand must be the same as that seen on the Blue Earth and its tributaries, and on the Waraju in Brown county (see the second annual report, pages 133 and 185). It there lies on the Lower Silurian unconformably. Here it seems to be underlain by an older member of the Cretaceous the Austin rock. This indicates the earlier submergence of this portion of the state beneath the ocean of the Cretaceous age, and the approach of the Cretaceous ocean from the east or southeast. As to the relative ages of this dislodged clay and white sand, there is no way of deciding which is the older from any certain evidences in Mower county. But in Brown county there is a bluish-green clay that overlies the white sand.

This rock is also wrought on the right bank, just above the mill, showing here also the same features.

At Sargent's spring, SW. ¼ sec. 31, Redrock, there is apparently an exposure of this white sand below the level of the water of a little pool. This place is a local celebrity. Pure, soft water boils up over the area of about a square rod, and sometimes over double that area, and can be seen issuing from the ground, bringing with it clean, white sand. The bottom of the pool presents a beatiful appearance. The water is as clear as crystal, and the boiling points which appear by reason of the rising white sand, in the midst of the darker sediment, can be minutely inspected at a depth of five or six feet. Running a stick into the agitated sand, it soon strikes a sandrock which is doubtless the source of the boiling sand, and the same bed that furnished that at the quarry in Dobbin's creek.

On the SE. ¼ sec. 12, Windom, Mr. Thomas Smith has struck the Cretaceous in making explorations for coal. From Mr. Smith the following account of his efforts was obtained. His attention was first attracted by a "scum that stood on stagnant water" and by the "mud brought up on horses feet" in crossing the creek bottoms. Having chosen a locality along the bank of Rose creek which he judged suitably free from water, he began to drift into the bank of the creek following a bed of vegetable material that had the appearance of old peat, but which contained some coarse pieces of fibrous wood. The choice of this place was altogether accidental, the desire being to obtain a place free from water. There were no surface indications favoring coal at that point. He accidentally came upon the peat bed. At first the peat, of which Mr. Smith has preserved samples, and which consists entirely of comminuted vegetable fibre, was only half an inch thickness. In the coarse of the drift it gradually thickened at 70 feet, to 18 inches in thickness. This drift was nearly level, inclining a little for the sake of drainage. On the top of this peat, pieces of wood which were judged to be of pine and cedar, of which also Mr. Smith has pieces preserved, were found in abundance. One large piece was two feet long and ten inches in diameter, supposed to be pine. This drift was about 50 feet below the general surface and 6 or 7 feet above low water in Rose creek. Above it was a blue clay with gravel stones. Below it was also a dark blue clay with gravel stones. This peat seems to have been in a genuine ancient peat lake, filled or partly filled, on which

ated pieces of wood from the surrounding forest. The iole was buried again by glacial deposits fifty feet thick.* This drift having been abandoned at 80 feet, a shaft was nk twenty rods toward the SW. to the depth of 50 feet, eting the same peat. This shaft passed through fifteen et of sand, ten or twelve feet of yellow clay, and about 23 et of gravelly blue clay. Then east of the drift 40 rods a aft was sunk on lower ground, but not on the bottoms, ough somewhat within the general valley. The section re was, as given by Mr. Smith:

No. 1. Soil and gravel	5 feet
No. 2. Gravelly blue clay	4 or 5 feet
No. 3. Gravelly yellow clay	14 feet
No. 4. Blue clay, not gravelly	9 feet
No. 5. Brown, waxy clay, fine	6 inches
No. 6. Rock with water, (Mr. Smith says a specimen of "blue slate" came from this level)	3 feet
No. 7. A soft rock which furnished fine drillings that were taken for coal	4 feet

n this drill, the first 22 feet of which were a shaft, Mr. ith next came upon a very hard rock, and as all his work s done by hand he did not succeed in entering this stratum, r in getting a specimen.

At this point Mr. Smith made efforts to get help from the inty commissioners but they declined. He next sank a aft forty feet in depth, about twenty feet from the last, eting about the same materials, except that here there s no "blue clay, not gravelly," and no "fine, waxy, brown y." He struck the rock at the same depth. The bottom the "gravelly yellow clay" here was hard "like brick," mented by deposits from the water which came in from low immediately after penetrating through it. This was shaft throughout. Here the work stopped.

On visiting the last shaft which was all dug, the rock ruck is seen in fragments lying about. It is a fine sand- one now rusty brown with iron, but which on being taken t was at first of a bluish gray color, like the deeply cut istin stone. This is somewhat coarser than that and more osely grained, but in every other respect appears to be the me rock.

*This peat was again struck in a shaft twenty rods further SW. from the drift, d was there about a foot thick, and about the same depth below the surface. It s met in wells two and a half or three miles northwest, at thirty-five feet.

The Devonian.

The most westerly outcrop of these limestones within the county, is that on Mr. Andrew Robertson's land, sec. 26, Windom. The rock here seen is course and porous, but rather firm, and very slightly exposed. It occurs in the valley of a small tributary of Rose creek.

The quarries at Le Roy are owned by Joseph Brevier, Judson A. Palmer, Stephen Drowne, and the heirs of L. Johnson.

The quarry owned by the heirs of Johnson is about forty rods from the state line, in sec. 35, Le Roy. It is in a lightly timbered tract of country, accompanying the upper Iowa river, and about ten rods south of the river. The beds rise to within a foot or two of the surface, on the angle of the river bluff, though the bluffs of the river are not conspicuous, the depth of the valley being only about twelve or fifteen feet below the general level, and broad and basin-like. The foreign drift about is light, but some large boulders are scattered about. This stone is light colored (nearly white) hard and fine, exactly like the Devonian seen near Northwood, in Iowa, though in heavier beds than that. It would make a beautiful white marble. It is uniform in grain and texture, and not in the least porous. With the exception of one or two layers of an inch or two of green clay, the beds are all of this limestone, exposed twelve feet.

At Palmer's quarry the rock is overlain by six inches of soil, though a hundred rods from the river. These beds are all badly weathered so far as opened, and of the same general character as at Johnson's. No drift. Exposed three feet.

Mr. Palmer's other quarry is in the river bluff, and easy of access. The stone is the same as that already described, and has been burned near the quarry for quicklime. It forms a bluff, exposing about twenty feet.

Brevier's quarries, of which two are opened, are in the left bank of the Upper Iowa river, and show about the same beds as seen in the other quarries.

Drowne's quarry is also in the bank of the river, but shows only about six feet, though there is every opportunity for opening the beds to a greater depth. There is here a much more argillaceous and fissile bed than any seen in the other quarries. It is about eighteen inches thick. This layer, coming about midway in the quarried beds facilitates the working of the quarry, but is itself of no value. In

the débris thrown out, probably from this layer, a globular mass of *Cœnostroma* was obtained, which, taken with the lithological resemblance of the rock to that containing Hamilton fossils at Northwood, in Iowa, near the Minnesota state line, satisfactorly establishes the Devonian age of the whole of the rock at Le Roy.

Section 16, Le Roy, Mrs. Alice Plummer owns a newly opened quarry near the river.

There is an exposure of the limestone in the valley of the Upper Iowa, near the west line of the SE. ¼ of NW. ¼ of sec. 29, Le Roy. There is here a boiling spring coming out of the rock in the bed of the creek. The rock is also exposed just over the state line, in Iowa, on the Little Cedar, and more particularly at Staceyville, two miles south of the line.

The Silurian.

As already stated, the rock at Frankford is classed as Silurian on lithological evidence only. The quarries here, beginning with the highest up the creek (known as Dear creek) are owned in the following order: A. Bush has a quarry about four miles above Frankford; G. Fryer has a good quarry; E. W. Elder burns and sells lime at Frankford; L. Patchin's quarry is situated in the brow of a small valley tributary to Deer creek, and consists of beds that are much shattered and weathered, so as to afford irregular and small pieces, considerably used for lime. Exposed about seven feet. These beds overlie or are very near the tops of the beds in the next—that of Mr. J. Hawkins. This is in the bluff of Deer creek, and supplied the heavy stone placed in the abutments of the highway bridge at Frankford. The exposure here is about twenty feet. The layers are three feet and more in thickness, and project over the water. This is a characteristic exposure. The rock is different from that at Le Roy. It is of about the same color, somewhat darker, vesicular and porous. It is firm, has abundant calcite, and some chert. While it is plainly fossiliferous, no fossils demonstrating its age are obtainable. J. C. Easton also owns a quarry at Frankford, back from the creek, on the open prairie. Other outcrops occur favorable for quarrying. In the scarcity of fuel, but little lime is made at Frankford. Much more is burnt at Spring Valley.

A stone quarry is opened two miles northwest of Grand Meadow, on Bear creek, owned by Mr. Coin. Another is 2½ miles east of Coin's, owned by Mr. I. O. Huffdaw.

The drift.

In Mower county no diminution of the drift was noticed. It consists of the usual hard-pan clay. This clay shows a light color for the first 10 or 15 feet, and below that depth is apt to be blue. Gravelstones and boulders are disseminated through it. Some of the boulders are very large and consist of granite. Some very large granite boulders occur near Rose creek village, lying on the surface, and some are near Adams. There are some also in the valley between Adams and Le Roy. Near Mr. Alderson's quarry at Austin a granite boulder has been blasted and broken for building stone. It is at least 16 feet long by 12 feet wide. Its depth is unseen. Others were seen equally large in various parts of the county.

The most interesting development in respect to the drift in Mower county consists in the discovery of an ancient bed of peat by Mr. Smith in Windom. The reader is referred to the account of his operations for coal, already given, for the particulars of this discovery. This bed of peat seems to be of considerable extent, superficially. A similar deposit is struck in wells at Le Roy. Mr. J. D. Wilsey, on sec. 31, met it at 20 feet. Mr. Porter, who dug his well, describes the deposit there as largely made up of distinct woody fiber, among which he thought he recognized hemlock bark. Several other instances of striking this buried vegetation are reported in the neighborhood of Le Roy. The clay overlying the peat bed is described as a gravelly yellow clay.

In the state of Iowa an ancient peat has also been met with at a number of places. Dr. White describes it at Davenport, at Iowa city, and in Adair county (*Geology of Iowa*, 1870, Vol. 1, p. 119) and refers its origin there to marshes that accompanied the valleys of the rivers near which the peats occur, when those rivers spread wider, and flowed at higher levels. But in Mower county the peaty deposit is not confined to the valleys of streams, nor to the proximity of streams. Mower county is on one of the highest divides in the state of Minnesota, and from it flow the sources of streams toward the north, south, and east. Those streams are small and never could have flooded the extent of country in which this peat is found. The positive information now at hand in reference to this peat deposit in Mower county, does not warrant confident assertions as to its origin. From all accounts it appears to be embraced

·een glacial deposits of gravelly clay, and it seems to k a period of interglacial conditions where coniferous s and peat mosses spread over the country. Peat mos- ıre not necessarily restricted to low, wet places. If the ›sphere be moist they will flourish on any surface, and ıccumulation of good peat may take place on a bare. ;y mountain-side. There are extensive marshes now ex- g in northern Minnesota, mainly covered with ericaceous ts, with some cedars and tamaracks, that are forming ense peat deposits. With an increase in the amount of sture of the air such peaty accumulations would spread · much higher levels. A return of glacial conditions ld bury such marshes below the deposits that are known rift.

t Le Roy Mr. Porter seems also to have discovered, just ıe border of the village, an old valley, now filled with l. His cistern was dug in the solid rock, which was met even feet. A well was bored fifteen feet distant toward river, to the depth or 32 feet, in sand, without meeting rock. Between this well and the river other wells have .ck the rock at several places, and usualy at about twelve . On the prairie throughout the county wells get water erally within thirty feet.

Material resources.

'ith the exception of the central hight prairie portion of ver county, it is tolorably well supplied with wood for mon fuel. On the prairies referred to wood is costly. t portion of the county is thinly settled with farmers. ıg the valleys of the streams in the eastern and western ;ions of the county, the first settlements took place, and ıose valleys are found the most of the population at this ›. The principal natural wealth of the county lies in its and its agricultural adaptations. The people are gen- ly farmers. The growth of the county in all respects be primarily dependent on, and co-ordinate with the set- ıent of the farming lands, and their profitable tillage. re is some water power in the county, as at Austin, and ›w Austin to the county line, and at Le Roy and Ramsey. it is well improved in the erection of flouring mills. wer county contains no peat, and cannot hope for coal. › rocks that underlie the county cannot be depended on producing anything but building stone and quicklime. the former, some of the limestone would produce of good

marble, if properly handled. That is the case particularly at Le Roy. For making quick-lime there is amply opportunity. The only difficulty will be a competition with other localities from which transportation is light, that posses cheaper fuel for calcination. Brick can be made at almost any place in the county. Three miles northeast of Lansing Mr. John Just is engaged in brick-making. At Austin Mr. A. H. Alsip now manufactures brick. Formerly they were also made by Smith, Tuttle and Tracy, and by Horace Webb. Mr. Alsip lays his own brick in the wall for $12.50 and $13.00 per thousand, furnishing everything. He sells for $12 and $15 per thousand. He makes a sand-mold brick, free from lime, but rather soft. He burns the common surface, taking off about three inches, so as to remove the grass-roots. During the year he has made about 550,000, oak wood costing about $6.50 per cord. At Austin a light colored brick from Watertown, Wisconsin, is somewhat used. Brick from Chaska, Carver county, are delivered on the cars for $8, costing $13 at Austin. The lime used at Austin is mostly from Mitchell, Iowa. At Le Roy not many brick have been made. The Caswell house and the school house at that place are built of brick made at Le Roy. The quality of the Le Roy brick is as good as any seen at Austin. About three miles above Frankford the Shaw Brothers have begun the manufacture of a fine light-colored brick, though some are also red. This yard is said to turn out some of the best brick made in the county. To those interested in burning lime in the county the following statements obtained from Schuyler and Hulme, of Mitchell, Iowa, extensive lime-burners, will be of value. They have one draw kiln, which is in constant operation, of Page's patent, from Rochester, New York. It affords 200 bushels of quick-lime every 24 hours. It requires 48 hours to take a piece of the rock through the kiln. Every 24 hours four cords of wood are consumed, at a cost of four dollars per cord. One cord of stone is calculated to make 100 bushels of lime, at 80 pounds per bushel, which sells at the kiln at 35 cents per bushel, average price. Coarse lime will fall six pound short by measure, but if the fine lime be put in it will hold out weight, previous to being air-slacked. Air-slacked lime averages about 55 pounds per pushel. To run this kiln requires seven men, including those who take out the stone, or five men and one team.

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THE GEOLOGICAL

AND

NATURAL HISTORY SURVEY

OF

MINNESOTA.

THE FOURTH ANNUAL REPORT.

FOR THE YEAR 1875.

By N. H. WINCHELL, State Geologist.

ASSISTED BY

M. W. HARRINGTON, of the University of Michigan.

SUBMITTED TO THE PRESIDENT OF THE UNIVERSITY, DEC. 31, 1875.

SAINT PAUL:
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1876.

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STATE PUBLICATIONS RELATING TO THE GEOLOGY OF MINNESOTA.

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1. *Sketch of the Lead Region, by Dr. D. F. Weinland, with a statement of the objects of a geological and natural history survey.* 34 *pp.* 1860. *Reprint from the Wisconsin Reports for* 1858. *Out of print.*
2. *Statistics and History of the Production of Iron, by A. S. Hewitt.* 47 *pp.* 1860. *Reprint of a paper read before the American Geographical and Statistical Society, January* 31, 1856. *Out of print.*
3. *Report of Anderson and Clark, Commissioners on the Geology of the State, January* 25, 1861. *8vo.* 26 *pp. Out of print.*
4. *Report of Hanchett and Clark, November,* 1864. *8vo.* 82 *pp. Out of print.*
5. *Report of H. H. Eames, on the Metalliferous Region bordering on Lake Superior,* 1866. *8vo.* 23 *pages.*
6. *Report of H. H. Eames, on some of the northern and middle counties of Minnesota.* 1866. *8vo.* 58 *pp. Out of print.*
7. *Report of Col. Charles Whittlesey on the Mineral Regions of Minnesota.* 1866. *8vo.* 52 *pp. close type, with wood cuts.*
8. *Report of N. C. D. Taylor on the Copper District of Kettle river, incorporating Mr. James Hall's estimate of the copper prospects of that district,* 1866. 2 *pp. 8vo. Found only in the Executive Documents.*
9. *Report of a Geological Survey of the vicinity of Belle Plaine, Scott county, Minnesota. A. Winchell. June* 17, 1871. *8vo.* 16 *pp.*
10. *The First Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1872. *By N. H. Winchell. 8vo.* 112 *pp. with a colored geological map of the State. Published in the Regents' Report for* 1872. *Out of print.*
11. *The Second Annual Report on the Geological and Natural History Survey of the State, for the year* 1873. *By N. H. Winchell and S. F. Peckham. Regents' Report;* 148 *pp. 8vo; with illustrations.*
12. *The Third Annual Report on the Geological and Natural History Survey of Minnesota, for the year* 1874. *By N. H. Winchell.* 41 *pp. 8vo. with two county maps. Published in the Regents' Report for* 1874.

[NOTE.—Of the foregoing, Nos. 1, 2, 4 and 6 are wanted by the Survey.]

ADDRESS AND SUMMARY STATEMENT.

To the President of the University:

The accompanying report, the fourth since the beginning of the Geological and Natural History Survey of the State, embraces full and detailed reports on the counties of Fillmore, Olmsted, Steele and Dodge. These counties lie nearly contiguous in the southeastern portion of the State, embracing some of the first settled, and now most thickly inhabited counties of the State. The plan for the season embraced other counties, in the central portion of the State, and one or more in the noithern. But it has been found im possible to complete more than the four named. Considerable work has been done in Hennepin county, and some in Stearns, but the scattered observations made will be reserved till the work in those counties is taken up and reported in detail. The complicated character of the work done in Fillmore and Olmsted counties will be seen by a glance at the accompanying geological maps of those counties. The eastern portion of these counties, particularly Fillmore, falls within that well-known tract denominated by Prof. J. D. Whitney, a "driftless area." This term very nearly describes the tract as represented in this portion of Minnesota, but I have been able to discern, even in the most eastern part of Fillmore county, occasional small deposits of true northern drift, as detailed by localities in the report on that county. In the absence, or attenuation, of the true northern drift, the underlying rocks make bold and frequent outcrops, governing the immediate contour of the surface, and deciding the agricultural as well as the general industrial resources of the country. It has been necessary, therefore, to give very minute attention to the lines of outcrop of the different formations as they make their way across the county, in order to delineate them correctly on the accompanying colored maps.

In the survey of these counties I have had the assistance of Mr. W. E. Leonard, a student of the University, who accompanied me

in the earlier part of the season in Fillmore county, and of Prof. M. W. Harrington, of the University of Michigan, whose report is herewith presented. Prof. Harrington, who ably carried on the work independently in my absence, was compensated only by the payment of his field and traveling expenses. He also had the privilege of retaining such botanical specimens as he could gather, for the purpose of enlarging the already magnificent collection of plants in the museum of Michigan University, a list of all identifications being reported for our survey.

The catalogue of the plants of the State, by Dr. I. A. Lapham, mentioned in the report for 1873, has been printed by the State Horticultural Society, and is published in its report for 1875, where it is duly accredited to the Geological and Natural History Survey, to whose care Dr. Lapham had entrusted it.

In December, 1872, the Board of Regents adopted a resolution asking the representatives and senators in Congress, from Minnesota, to take measures to secure to Minnesota such determinations of latitude and longitude, by the United States Lake Survey, as are done in other States by the officers of that survey. Through the co-operation of Hon. M. H. Dunnell, representative in Congress, the Superintendent of the Lake Survey, Gen. C. B. Comstock, was induced to take immediate steps toward the determination of the latitude and longitude of the University buildings. There being no Congressional appropriation for further determinations in this State, nothing further has been done. It is desirable, in order to construct a correct map of Minnesota, that as many points as possible be established in the same manner. In the State of Michigan, the Lake Survey officers are determining one or more points in each county of the Southern Peninsula. It is done by special act of Congress, appropriating money to enable the Lake Survey to aid the State Survey. I call your attention to this matter, that further efforts may be made to carry out the intent of the original action of the Board of Regents. It is the established policy of the general government to aid those States that are carrying on geological surveys, through the instrumentality of the coast surveys, and it has been so announced. The attention of Congress should be called specially to this matter, in order that our survey may receive its share of such aid.

The following has been sent from the office of the Lake Survey, at Detroit, by order of Gen. Comstock, giving the results of observations made at the University:

Longitude of the Smaller Cupola of the University of Minnesota.

	Longitude.	References.
Longitude of Washington (Naval Observatory) west from Greenwich.	77° 08′ 00″ .00	Admiral Sand's letter, February 9, 1872.
U. S. Lake Survey observatory (1857 to 1870) west from Washington (Naval Observatory.)	5 59 59. 80	L. S. Report 1871 and Office No. 8.
S. E. corner of the new Custom House, St. Paul, Minn., west from the L. S. Obs. (1857 to 1870.)	10 02 32. 25	L. S. Report 1872 and Office No. 8.
Smaller Cupola of the University of Minnesota west from the S. E. corner of the new Custom House.	0 8 36. 50	See office rept. No. —. A. R. Flint, obs'r. T. Russell, computer.
Longitude of the smaller cupola of the University of Minnesota from Greenwich.	93° 14′ 08″. 60	

	Latitude.	References.
Latitude of the S. E. corner of the new Custom House.	44. 56 42. 89	Office No. 8, from A. R. Flint, observer, 1871.
Smaller Cupola of the University of Minnesota north from the S. E. corner of the Custom House.	1 56. 33	Office rep. No. 213. A. R. Flint, ob'r, T. Russell, c'p'r.
Smaller Cupola of the University of Minnesota.	44° 58′ 39″. 22	

	Latitude.	Longitude.
Smaller Cupola of the Univ. of Minnesota	44° 58′ 39″. 22	93° 14′ 08″. 60

(Signed) O. B. WHEELER,
Compiler.

In regard to chemical work I am not informed that anything has been done since the report of 1873. From time to time the following substances have been submitted to the chemist of the survey for examination. This list is here given that the records of the survey may be easily consulted, and that in future analyses samples may readily be referred to their sources.

No. 1. Light, pinkish clay, known as "Tripoli," from Stillwater, Minn. Submitted to Prof. Strange December 10th, 1872. Reported on by Prof. Peckham. (See the Second Annual Report.)

No. 2. Red and yellowish clay, fine grained; no apparent pebbles nor sand. From Spring Valley, Minn. Submitted to Prof. Strange December 10th, 1872.

No. 3. Drab, or brown clay, with a reddish tinge, very fine and soapy to the touch; no sand nor pebbles. From Spring Valley, Minn. Submitted to Prof. Strange December 10th, 1872.

No. 4. Same as No. 2, but evidently arenaceous, and with occasional small pebbles. From Spring Valley, Minn. Submitted to Prof. Strange December 10th, 1872.

No. 5. Peat, from Schmidtz' land, St. Paul, Minn., eight feet below the surface. Submitted to Dr. P. B. Rose August 6th, 1873. Reported November 22d, 1873. (See the Second Annual Report.)

No. 6. Peat, from Schmidtz' land, St. Paul, Minn., 2 feet below the surface. Submitted to Dr. P. B. Rose August 6th, 1873. Reported Novem ber 22d, 1873. (See the Second Annual Report.)

No. 7. Manufactured Peat, from Wells; W. Z. Haight. Submitted to Dr. P. B. Rose, August 6th, 1873. Reported by him November 22d, 1873.

No. 8. Peat from Lake Emily, near St. Peter, Minn. Submitted to Dr. P. P. B. Rose, August 6th, 1873. Reported November 22d, 1873.

No. 9. Turf-peat, from Empire City. Submitted August 6th, 1873, to Dr. P. B. Rose. Reported November 22d, 1873.

No. 10. Peat from Wells, not manufactured. Submitted August 6th, 1873, to Dr. P. B. Rose. Reported November 22d, 1873.

No. 11. Cretaceous coal, cannel, from Crow Creek, near Redwood Falls, Minn. Submitted to Prof. S. F. Peckham, Sept. 6th, 1873.

No. 12. Coal, from the surface, near Bismarck, D. T. Submitted to Prof. S. F. Peckham, September 6th, 1873. [The last two have the same external characters.]

No. 13. Earthy coal, from Crow Creek, near Redwood Falls, Minn. Submitted to Prof. S. F. Peckham, September 6th, 1873.

No. 14. A mixture of charcoal and ash, apparently, from the lignite beds of the cretaceous, at Redwood Falls, Minn. Submitted to Prof. S. F. Peckham, September 6th, 1873.

No. 15. Kaolin; the result of decomposed granite, greenish, with no apparent grit. From Birch Coolie, Minn. Submitted to Prof. S. F. Peckham, September 6th, 1873. (See description of this substance, and of the locality, in the Second Annual Report.)

No. 16. Peat, from St. Cloud, 18 inches below the surface. Submitted to Prof. S. F. Peckham, September 15th, 1873. Partially analyzed and reported December 23d, 1873.

No. 17. Peat from Lura, Faribault county, Minn., 18 inches below the surface. Land of W. Z. Haight. Bog A. Submitted to Prof. S. F. Peckham, October 9th, 1873. Partially analyzed and reported December 23d, 1873. (See the Second Annual Report.)

No. 18. Peat from the same bog as No. 17, 3 feet below the surface. Submitted to Prof. S. F. Peckham, October 9th, 1873. Partially analyzed and reported December 23d, 1873.

No. 19. Peat from Lura, Bog B, 18 inches below the surface. Submitted October 9th, 1873, to Prof. S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 20. Peat from the same bog as No. 19, 3 feet below the surface. Submitted to Prof. S. F. Peckham, October 9th, 1873. Partially analyzed and reported December 23d, 1873.

No. 21. Turf-peat, from the land of John Haggard, section 4, town 101, range 39. Submitted October 9th, 1873, to Prof. S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 22. Peat from K. K. Peck's land, near Windom, 3 feet below the surface. Submitted October 9th, 1873, to Professor S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 23. Peat from K. K. Peck's land, near Windom, 2 feet below the surface. Submitted October 9th, 1873, to Professor S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 24. Peat, from the land of Rev. Edward Savage, near Windom, Minn., 18 inches below the surface. Submitted October 9th, 1873, to Prof. S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 25. Turf-peat, from S. O. Taggart's land, section 24, town 105, range 35. Submitted October 9th, 1873, to Prof. S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 26. Peat from land of A. A. Soule, Mountain Lake, Minn., 2 feet below the surface. Submitted October 9th, 1873, to Professor S. F. Peckham. Partially analyzed and reported December 23d, 1873.

No. 27. Peat from the land of the St. Paul and Sioux City Railroad, section 13, town 106, range 37, 2 feet below the surface. Submitted to Prof. S. F. Peckham, October 9th, 1873. Partially analyzed and reported December 23d, 1873.

No. 28. Peat from the land of F. G. Taylor, Brooklyn, Hennepin county. Submitted to Prof. S. F. Peckham, October 9th, 1873. Partially analyzed and reported December 23d, 1873.

No. 29. Lumps from the sandstone near the Red Jacket Mills, in Blue Earth county, apparently magnesia, or magnesia and lime. (See description of that locality in the report for 1873.) Submitted to Prof. S. F. Peckham. Partially examined and reported December 23d, 1873.

No. 30. Green specks in the *St. Lawrence limestone.* Sample from St. Lawrence. Submitted to Prof. S. F. Peckham. Partially examined and reported December 23d, 1873.

No. 31. Green specks from the *St. Lawrence limestone.* Sample from Judson. Submitted to Prof. S. F. Peckham. Partially examined and reported December 23d, 1873.

No. 32. Black mineral, accompanying quartz. The quartz occurs in decomposed granite, at Minnesota Falls. The mineral has the appearance of specular peroxide of iron, but is thought by the owners to be a mineral of value. Submitted to Prof. S. F. Peckham, who pronounced it haematite iron ore. (See the description of this locality in the Second Annual Report.)

No. 33. Turf-peat, town 101, range 40, section 27. Submitted to Prof. S. F. Peckham, March, 1874.

No. 34. Peaty lake sediment, Bigelow, Minn. Submitted to Prof. S. F. Peckham, March, 1874.

No. 35. Peat, from Red Wing, land of Capt. O. Eames. Submitted to Prof. S. F. Peckham, March, 1874.

No. 36. Peat from C. F. Bryan's land, near Winona, Minn. Submitted to Prof. S. F. Peckham, March, 1874.

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No. 37. Ore from the Sauk Valley, said to have been taken from the bottom of a shaft sunk in exploration for coal. Submitted to Prof. S. F. Peckham.

No. 38. Ore, supposed to be of silver, from Colorado, from J. B. Culver. Duluth, Minn. Submitted to Prof. S. F. Pechham, September 15th, 1874. Reported to Mr. Culver.

No. 39. Ore, supposed to be of silver, from E. F. Kindred, Brainerd, Minn. Submitted to Prof. S. F. Peckham, September 18th, 1874. Reported to Mr. Kindred.

No. 40. Ore, supposed to be of silver, from the north shore of Lake Superior, near Duluth, from H. Burg. Submitted to Dr. P. B. Rose, November 20th, 1874. Reported December, 1874, and forwarded to Mr. Burg.

No. 41. Ore from M. L. Casey, supposed to be of iron, from the corporate limits of Duluth. Submitted to Prof. S. F. Peckham, December, 1874.

No. 42. Sample of mineral water from the Belle Plaine Salt Springs. Submitted to Prof. S. F. Peckham, October, 1873. Partially analyzed and reported December 23d, 1873.

No. 43. Fragment of native copper, apparently, from R. S. Russell, Pleasant Grove, Olmsted county. Submitted to Mr. D. P. Strange in the winter of 1872 and '73. Reported by Prof. S. F. Peckham, December 23d, 1873.

No. 44. Sample of water from the Belle Plaine Salt Springs. Submitted to Prof. S. F. Peckham, October, 1873. Partially analyzed and reported February 16th, 1874.

The accompanying report also embraces a statement of operations in the Museum since the date of the last report thereon. The law ordering the Geological and Natural History Survey contains a clause as follows:

SEC. 6. It shall be the duty of said board of regents to cause proper specimens, skillfully prepared, secured and labeled, of all rocks, soils, ores, coals, fossils, cements, building-stones, plants, woods, skins, and skeletons of animals, birds, insects and fishes, and other mineral, vegetable and animal substances and organisms discovered and examined in the course of said surveys, to be preserved, for public inspection, free of cost, in the University of Minnesota, in rooms convenient of access, and properly warmed, lighted, ventilated and furnished, and in charge of a proper scientific curator. * * *

This clearly establishes in the University a State Cabinet or Museum of Natural History. A report on the progress of the survey, in compliance with law, implies a report on the condition of its collections. Hence it seems proper that hereafter the report on the museum should be embraced in that on the progress of the survey. With the establishment of the State Museum at the University

arises the necessity for cases for the exhibition and proper keeping of the collections, and other current expenses involved in their transportation, labeling and custody. Objects of Natural History, requiring careful and often expensive preparation, must be constantly watched and frequently cleansed, to prevent their deterioration and destruction. The mounting of mammals and of birds is expensive. To carry on a system of exchanging, with other institutions, as ordered by the law, involves an outlay of money. None of these expenses have been provided for. The legislature should make an annual appropriation of several hundred dollars to enable the Regents to carry out that part of the law. It will require, at once, about a thousand dollars to fit up the rooms assigned to the use of the Museum, with suitable cases and other appliances.

I wish to call to your serious attention, the propriety of taking steps to place on an active footing other portions of the work ordered by the general law of March, 1872. Sundry practical questions involving the industries of the state and the confort of the people, have arisen since the inception of the survey; and the demand for their solution, by efficient means and in an authoritative manner, has sought expression in attempts at special legislation, creating special commissions for the purpose of investigation and report. These practical questions, which really depend, in their ultimate results, on the means taken to investigate under the guide of science, and to modify or control their operations, are covered by the terms of the general law of March, 1872. I refer to an examination of the peat deposits, and to the collection of statistics concerning the late incursion of the western grasshoppers into the state. If the general law were put into vigorous execution, with ample means, there would be no inducement to originate special commissions to perform the various portions of the work ordered. It seems to me these departments ought not to rest much longer without making a systematic beginning. If nothing more is done than to keep up an organization, with little expense, such organization would be ready in case any public emergency arises to take the work in hand, and to furnish information immediately concerning its proper treatment. In the mean time, any special commission, created to perform work required by the terms of the general law, should be made subject to the Board of Regents, and all official reports on scientific investigations, covered by that law, ought to be made as so much contributed to the progress of the Geological and Natural History Survey. Then the state will not find herself duplicating her employes, and performing twice the same service. Then all these in-

vestigations will be judiciously supervised, and the scientific work of the state will be harmonized in all its relations.

Germane to the work of the geological survey, is the collection of a set of the building stones, minerals, limes and soils of the state, for exhibition at the Centennial Exposition, to be held at Philadelphia in the year 1876. The State Board of Centennial Managers having requested the aid of the Geological Survey in making a suitable collection of the objects named, the Board of Regents, through their Executive Committee, authorized me to superintend their collection. Although the desires and plans of the State Board of Centennial Managers have been very widely published, and considerable personal appeal has been resorted to, the present condition of the meager collections thus far made does not warrant ardent expectations that this branch of the exhibition on the part of Minnesota will be creditably sustained.

In submitting this report, I take pleasure in acknowledging the aid of the people of the counties reported on, and especially of Prof. M. W. Harrington, of Ann Arbor, whose former connection with the geological survey of Michigan enabled him to conduct the field work independently, releasing me for other duties.

Very respectfully,

N. H. WINCHELL.

THE UNIVERSITY OF MINNESOTA,
Minneapolis, Minn., Dec. 31, 1875.

MAP OF MINNESOTA.

Showing Locations of the Counties.

Total area 83,531 Square miles.

REPORT ON THE GEOLOGY OF FILLMORE COUNTY.

Situation and Area.

Fillmore county lies adjacent to the State of Iowa, and is separated from the Mississippi river by Houston county. It lies next east of Mower county, which was reported on last year. It has a width, north and south, of four government towns, each six miles square, and a length, east and west, of six, making it one of the largest of the organized counties. Its area is about 864 square miles, or 553,081.77 acres, according to the records of the State Land Office. It contains no lakes, and but few acres that are unsuited to farm tillage. Preston is the county seat. Lanesboro, Spring Valley, Chatfield and Rushford are the principal towns.

Natural Drainage.

Root river, with its tributaries, drains nearly the whole of the county. The Upper Iowa river, which enters the county in Beaver and Bristol townships, receives a few small streams from the southern tier of townships. Root river, flowing toward the east, spreads out its tributaries north and south, like the rays of a fan, crossing the entire county from west to east. Many of the branches of Root river rise in the counties next west and north of Fillmore county, in a tract of country covered with northern drift. After entering Fillmore county, they soon enter canon-like valleys, and the drift becomes much lighter. They then converge toward the main valley, following deeply cut rocky valleys, and leave the county in one volume at Rushford, in the northeastern corner of the county. These streams furnish frequent water-power privileges, and a number of them have been improved in the erection of mills, which are scattered throughout the county as follows. There are, besides these, several smaller saw mills:

At Chatfield, two flouring mills.

On the southeast quarter of section 17, Chatfield, one flouring mill.

At Clear Grit, one flouring mill.

On section 31, Jordan, one saw mill.

At Preston, one flouring and one woolen mill.

At Carimona, one flouring mill.

At Forestville, one flouring mill.

At Ætna, one flouring mill.

At Fillmore, two flouring mills.

At Baldwin's Bridge, (section 21, Forestville,) one saw mill,—also fitted for grinding feed.

At section 24, Bloomfield, (De For,) one flouring mill.

At Granger, two flouring mills.

On South Root river, three flouring mills.

At Rushford, three flouring mills.

At Peterson, one flouring mill.

At Whalen, two flouring mills.

At Lanesboro, three flouring mills.

On Bear and Deer Creeks, in the northwestern part of the county, eight flouring and four saw mills.

At the Tunnel Mills, section 34, Sumner, advantage has been taken of the winding course of Bear Creek. The creek is enclosed on both sides by high rocky walls. A tunnel has been cut through a narrow neck, excavated in the rock, admitting the water, which falls again into the river, on section 34, producing a fall of 25 feet in 600 feet. The cut in the rock is 600 feet long, for the tunnel, and 100 feet for the tail race. At G. Weisbeck's Mill, a similar opportunity is offered. This is on section 11, Spring Valley. By a tunnel of 70 feet, through the "Hog's back," a fall of 17 feet 10 inches may be secured; and at the lime-kiln of Mr. J. H. Hall, near Weisbeck's, a tunnel of 125 feet will furnish a power of 20 feet. About 20 rods from Weisbeck's, a tunnel of 450 feet will afford 64 feet head of water. The rock is limestone, in horizontal bedding.

Surface Features.

That portion of the county which is covered with a thick deposit of foreign drift presents the usual monotony of surface, characteristic of the drift latitudes. This includes the most of the western range of townships across the western end of the county, and some portions of the next range east. There are, however, even within the drift area, a number of narrow, deeply cut valleys, with precipitous, rocky bluffs, having very much the nature of canons, like those of the driftless territories of the west. Toward the east

these deeply cut valleys are more numerous. All the little streams, and a great many narrow valleys that have no running water in them, have high, rocky bluffs along their whole course. These vallies and streams, constituting the drainage system of the county, converge toward the valley of Root river. The valley of this stream, with its principal tributaries, presents some of the most remarkable and instructive phenomena of erosion to be found in the state. It passes nearly at right angles across the strike of the formations. These are alternating limestones and sandstones, with an occasional bed of soft shale. The Trenton limestone, underlain by the easily eroded St. Peter sandstone, the same as at the falls of St. Anthony, although about a hundred and sixty feet in thickness, is eaten into by the retroaction of the water as it plunges over the falls at the point where the streams cross the line of its superposition over the St. Peter, until they have each excavated in the Trenton a deep channel from 15 to 30 miles in extent. Through the line of strike of the St. Peter these valleys are widened out, the surface of the low ground within the bluffs being usually one of rich meadow with undulating surface, from one to two hundred feet below the general level. The Lower Magnesian Formation is entered upon by the streams while they are yet a good many miles within the general area of the Trenton. As this formation consists of three members. (two limestones, separated by a sandstone about 30 feet in thickness,) it repeats the succession of phenomena witnessed in the erosion of the Trenton and St. Peter. As the water leaves the Shakopee limestone and enters upon the Jordan sandstone, it passes over a series of rapids, or a fall of several feet perpendicular, which falls or rapids undergo a process of recession under the same causes as produce the recession of the Ttrenton-St. Peter falls. Again, when the stream passes from the St. Lawrence limestone upon the St. Croix sandstone the same conjunction of circumstances causes another rapid or water-fall. Thus by a series of steps, more or less evident, the branches of Root river descend from the area of the Galena limestone to the St. Croix sandstone. The valleys widen in the sandstone areas, and become abruptly narrow in the limestone belts. In passing down a stream, within a sandstone area, where the valley is perhaps half a mile wide, with tilled farms in the bottom land, the high bluffs being remote from the stream, the first indication of an approaching change in the formation is the rise of a terrace along the immediate river bank, with an occasional exposure of lime rock facing the water. This terrace, which becomes almost continuously rocky, rises slowly till it exposes the full

thickness of the rock which causes it. On the other hand, the first evidence of a change from limestone to sandstone, visible in descending the stream, is the occurrence of a waterfall or rapid. Such changes produce water-powers, many of which have been improved. Hence, the location of a flouring mill, on one of these branches, is an intimation to the geolgist that at that point one of his boundary lines crosses that stream. Around these points gathered the first village settlements. Preston is located where the water-power formed by the descent of the river from the Shakopee on to the Jordan induced the construction of mills. The water-power at Chatfield is formed in the same way. Near Fillmore the branches of Root river, known as Deer and Bear creeks, afford good water powers by their descent from the lower Trenton to the St. Peter. Mills have been built at both points. On the south branch of Root river, above Forestville, the stream leaves the Trenton, and the waterfall has been improved in the same manner, at Baldwin's Mill. The same fact is illustrated by a great number of eastward flowing streams, in the eastern border counties, between Fillmore county and the falls of St. Anthony at Minneapolis. Of course, rapids are also likely to be formed, especially in small streams, when passing through the areas of rock of uniform hardness. Such water-powers, and others that are formed by the construction of dams, do not fall into this class.

While the immediate valleys of Root river and its tributaries are apt to be rocky, the country that spreads out in either direction, after leaving the valleys, is not rough. It is rolling, or undulating. In the eastern portion the rocks are covered by a heavy deposit of rich, clayey, loam, known as the *loess*, which fills up many depressions and lends a uniform and remarkable fertility to the soil. It constitutes the soil. The farms are all well drained, naturally. The county contains no lakes. In York township there is a slough which on some maps is represented as a lake. It is about a quarter of a mile across. The Trenton area is distinctly separated, topographically, from that of St. Peter and the lower formations. From the Trenton to the Lower Magnesian the surface descends by a step or terrace, about 125 feet. Some of the Trenton areas are isolated from the main area, and constitute small tables or mounds, which are well known as "Trenton mounds" in the early reports. Some travelers have referred them to the agency of the ancient "mound builders," and a good many of the residents, who are not aware of the geological causes that have produced them, still believe that they are artificial instead of natural. From some of the elevated Trenton

areas, overlooking the river valleys, magnificent views of landscape may be had. From the elevated Trenton area in Newburg township, the eye looks over the valley of S. Root river, and can almost discern the Trenton bluffs on the opposite slopes of Root river in the northern part of the county. From the peninsula of the Trenton running north between Camp and Willow creeks, in Preston township, the village of Fountain is plainly discernible across the valleys of the S. Branch of Root river and Watson's creek, with a wide expanse of alternating timber and prairie between, while on either side is a broad undulating valley of prairie land. On the east is Camp creek valley, and on the west is that of Willow creek. These valleys are deep and wide, but owing to the thickness of the loess loam, the slopes are gentle and broad, and, in the fall of the year, when the industry of the farmer is exhibited in the plowing of his wheat fields, and the threshing of his last crop, in every direction may be heard the rattle of threshers, often running by steam, and may be seen a hundred teams preparing for the next harvest. Another magnificent view may be obtained from the Trenton peninsula on secs. 10 and 15 in Carrollton. From here the view extends north over the valley of Root river to the Trenton bluffs along the north boundary of the county, a distance of over forty miles, and toward the south over the valley of the S. Branch of Root river, looking over Preston and Lanesboro, which are situated within the river bluffs, so far below the general level of the country, that they can be seen but a short distance before reaching them. Further down Root river valley, the gorge in which the river runs becomes wider, being at Rushford, about two miles in width with fine farm lands in the bottoms. The bluffs are rounded off with age and have a thin soil, generally turfed, though showing frequent rock exposure. The river is there 565 feet below the tops of the bluffs, as measured by aneroid. At Whalen, in Holt township, the river is, by the same measurement, 470 feet below the top of the Trenton terrace on sec. 20. Whalen's Bluff is 250 feet high above the river. At Lanesboro, in Carrollton, the river is 285 feet below the immediate river bluffs, which consist wholly of the Lower Magnesian formation, and about 440 feet below the top of the Trenton terrace on sec. 20, Holt. At Preston the river at the stone mill is 335 feet below the Trenton terrace, which forms the general level about a mile south of the village. At Isinours Station the river runs 145 feet below the top of the Shakopee limestone which forms there the brow of the immediate river bluffs. At Forestville, the height of the country, north of the village, above the river, is 285 feet. The immediate

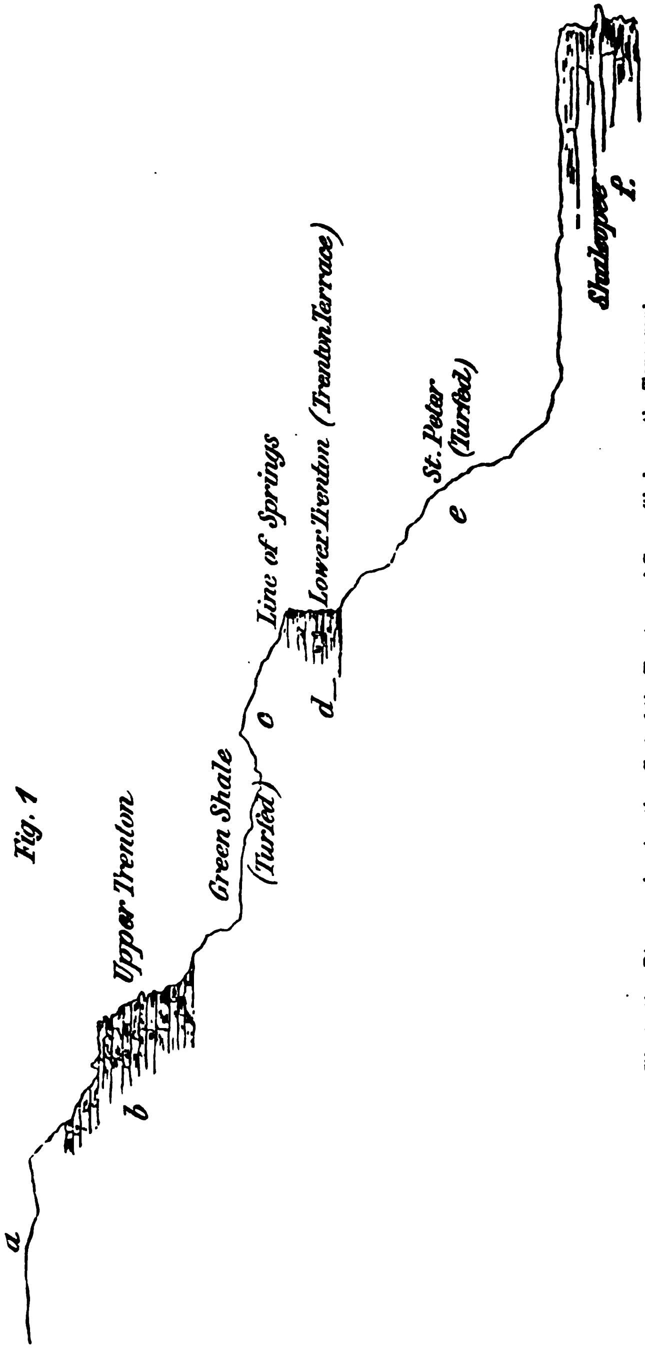
river bluffs are 190 feet above the mill pond. At Chatfield, the river is about 222 feet below the general level of the country. At Fillmore, the prairie upland is 200 feet above the river level. From Fountain to Isinours station, the track of the Southern Minnesota railroad descends 401 feet, passing from the upper Trenton to the St. Lawrence, and entering the latter formation about 25 feet, the rocks all lying nearly horizontal At Weisbeck's Mill, on Deer Creek, section 11, Spring Valley, the river is 205 feet below the general level of the country. There is here a little drift, but the cut is mostly in the Galena and Trenton limestones. The village of Fountain is about 350 feet higher than the terrace, at Preston, on which the Stanwix House stands. These measurements might be multiplied, but enough have been given to show the unevenness of the surface, due to erosion. The rocks lie everywhere nearly horizontal. The varied topography of the county is due to the influence of running water, and atmospheric forces, on the rocks, combined with their alternations of limestone with soft sandstone. The limestones are firm, and resist these forces much longer than the sandstones. They alternate in the following manner, in descending order:

Trenton limestone.
St. Peter sandstone.
Shakopee limestone.
Jordan sandstone.
St. Lawrence limestone.
St. Croix sandstone.

The limestones form the prominent features in the topography. They have the most frequent outcrops. They project along the summits of the bluffs, and constitute the brows of benches or terraces that diversify the county. The sandstones never, or very seldom, appear in the tops of the bluffs. They outcrop in sheltered nooks, or below the line of the limestone exposure. They are more likely to be hid by soil and turf. The lower Trenton contains, besides about 20 feet above the St. Peter sandstone, a layer of easily eroded green shale, which, outcropping by roadsides, introduces a series of springs and muddy spots, being impervious to water, that invariably follows that boundary line wherever it goes. It withstands the disintegrating action of the elements even more successfully than the limestones themselves. For that reason it protects that portion of the Trenton which lies below it, long after that which lies above it has been entirely denuded. The strike of the upper Trenton is often driven back several miles from that of the lower Trenton. The lime rock which lies below this shale is about 20 feet

thick. The singular Trenton mounds, which have already been mentioned, are composed of the lower Trenton protected by a greater or less thickness of the green shale, and a portion of the St. Peter sandstone. The subjoined diagram illustrates the manner of weathering down of the Trenton and St. Peter. Instances of this may be seen in almost any square mile, in the loam-covered area, along the outrunning strike of the Trenton.

Fig. 1



Illustrative Diagram showing the effect of the Trenton and Green Shales on the Topography.

At *a* the Trenton has its full thickness, about 160 feet. Such a point may be found at Fountain; *b* represents an outcrop of the upper Trenton, as seen along the gorges that are frequent in the Trenton area. Such an outcrop is visible at the "Big Spring," a few miles northwest of Fountain, where the water rushes out in a great volume near the base of the bluff, and probably on a level with the top of the Green Shale. At *c* is a marshy tract, or one that is gently sloping, having a springy margin, near the brow of the lower bluff. Such spots are visible particularly at Chatfield, in the northern part of the village, near Jacob's lime-kiln, and west of there. A fine illustration of the effect of this shale on the surface drainage may be seen in section 35, Holt, where a copious spring issues from near the top of the mound of Trenton, the water being shed by the shale overlying, and is gathered by troughs into a tank for watering stock. *d* represents the outcropping edge of the lower Trenton, It is this which is seen in the summits of the isolated mounds, and which forms the conspicuous shoulder that exists wherever the strike of the lower Trenton crosses the county. The slope *e* is occupied by the St. Peter sandstone. Sometimes this is quite precipitous, and its upper forty or fifty feet are very apt to be, but its lower portion is generally very gently descending, so that it is impossible to determine when it is replaced by the Shakopee which underlies it. The horizontal distance between *b* and *d* is sometimes several miles. This is apt to be the case along the eastern margin of the Trenton area. Indeed the detached Trenton areas in Holt and Amherst, and notably that in Pilot Mound, townships, comprise only this lower portion of the Trenton. The Shakopee limestone, *f*, underlying the St. Peter, is that which occurs along the tops of the immediate bluffs of the river, as at Preston, Lanesboro, Clear Grit and Whalen. At Chatfield it is seen at the mill, and rises about thirty feet above the river.

Throughout the Trenton area are found a great many depressions that are well known as "sink-holes." These consist of broken down spots in the drift, or loam, where it had been spread over a pre-existing canon in the rock. In some places they are very numerous, but they are confined, so far as known, with but a single exception, to the Trenton areas. They throw some light on the condition of rocky surface prior to the period which witnessed the spreading of the drift. The rock was wrought, at least in Fillmore county, in very much the same manner as we now see it along the river gorges. The immense valleys of erosion which we see, not only in Fillmore county, but also throughout the tract that has been denominated the "Driftless area," were excavated before the glacial

period. When the streams of the present time run in such gorges they have been so located by the exigencies of surface drainage and erosion since the glacial epoch. That these gorges antedate the glacial period is shown by their existence beneath the glacial drift. These sink-holes sometimes occur in lines, and with increasing frequency and size toward a large valley, and at last coalesce so as to form a continuous valley, though frequently without running water, that becomes tributary to the larger gorge. These gorges under the drift can sometimes be traced for some distance by a series of successive sink-holes. Sometimes streams are lost in them, and reappear at lower levels. There are several well-known subterranean passages in the county. Lost Creek, in Jordan township, and the Brook Kedron, in Sumner, both have underground passages for several miles. Canfield Creek, south of Forestville, runs underground about twelve miles, and, finally, the south branch of Root River sinks on the northeast quarter of section 19, Forestville, and runs underground, except in high water, to about the center of section 21, where it reappears again. These underground passages are in the area of the Trenton. They indicate the corrugated surface the country presented prior to the overspreading of the drift and loess loam. The Trenton cannot be supposed to have been any more subject to such causes as produced this channeling in the rock than the other formations of the Lower Silurian. There is some reason, however, why these gorges are found almost entirely confined to that limestone. As has been said, the rest of the Lower Silurian consists of alternating sandstones and limestones, which conduces to their breaking down laterally, the sandstones easily crumbling out. The Trenton limestone, on the other hand, while it has a thickness of 160 feet, more or less, has, near its base, a bed of impervious shale, which prevents the downward infiltration of the surface water, and protects the underlying sandstone. Hence the erosions that operate laterally, in tearing down the other Lower Silurian formations, are occupied, in the Trenton limestone area, in cutting narrow perpendicular gorges. For this reason the Trenton area is everywhere the highest in the county. From the eastern boundary of the Trenton, looking east, one beholds a broad landscape lying several hundred feet, in some places, below him, the effect of the more rapid denudation of the rocks of that portion of the county. Into such narrow gorges neither the drift nor the loess loam, however deposited, would enter with such compactness as to close up the pre-existing water courses; and when partially closed up, as they were wherever sink-holes have since appeared, they have been undergoing ever since a process of re-excavation. This

process is revealed in the occasional collapsing of the surface soil, and the formation of a new sink-hole, and in the enlargement of others, since the settlement of the county. The following notes on the various towns of the county show the distribution of timber, the area and the magnetic variation at the time of the United States township survey (1854.) The distribution of timber, however, as herein noted, varies somewhat from the actual facts as existing at the present time. The areas of timber as they exist now, are more correctly shown on the accompanying map, which is based on that of the county published in Andreas' Atlas of Minnesota.

In addition to the timbered areas as here noted, a great proportion of the county is covered with bushes which are composed of hazel, aspen, oak (two sorts) and, where these are wanting, a species of low willow which seems to come up first after the prairie fires are stopped. After the willow, hazel and oak and aspen gradually come in, and in time convert the original prairie to a bushy or timbered region. Over a great deal of the county this process is going on. There are thousands of acres of young native timber not exceeding five or six inches in diameter.

The general elevation of the county above the sea may be seen from the following points along the Southern Minnesota R. R.:

Rushford Depot	711 feet.
Lanesboro Depot	881 feet.
Isinour's Station	888 feet.
Fountain Depot	1,289 feet.
Grand Meadow, Mower County	1,825 feet.

Notes from the Surveyor's Plats of Towns of Fillmore Co.

Newburg. T. 101 *N., R.* 8 *W.*

A large portion of this town is prairie. In the N. W. corner the S. Branch of Root river introduces a broken and wooden tract in secs. 6, 5 and 4. Thickets of small timber are found in the central and southwestern portions, and also in the northeast. Magnetic Variation 4° 45′ to 9° 22′. Area, 23,045.54 acres.

Preble. T. 102 *N., R.* 8 *W.*

This town is mainly wooded. It is crossed in the northeasterly direction by the south branch of Root river, which, with its tributaries brings in a great diversity of surface. There is a small

prairie patch in sections 25, 26, 34, 35 and 36. Magnetic Variation 6° 10′ to 9° 12′. Area, 23,053.60 acres.

Norway. *T.* 103 *N.*, *R.* 8 *W.*

An irregular patch of prairie enters this town from the south and west, becomes narrow in the central portion, but expands to three miles in extent N. and S. in the northeastern. This prairie belt is a divide between the tributaries of the South Branch and of Root river, and is broken into by the bluffs that accompany those tributaries and extend beyond the limit of flowing water. Variation 6° 46′ to 9° 10′. Acreage, 23,012.08.

Rushford. *T.* 104 *N.*, *R.* 8 *W.*

The only prairie land found in this town is that along the bottom land of Root river lying within the rock bluffs. This is marshy, except along the tributary valleys. Root river crosses the central part of the town, and flows several hundred feet lower than the level of the adjoining country. Magnetic Variation 5° 45′ to 9° 6′ Acreage, 23,149.13.

Canton. *T.* 101 *N*, *R.* 9 *W.*

This township is wooded, except in the northeastern and southeastern portions, and a small area entering from the west covering secs. 18 and 19. Mag. Var. 7° 5′ to 10° 56′. Acreage, 23,054.32.

Amherst. *T.* 102 *N.*, *R.* 9 *W.*

The larger portion of this town is prairie, broken with patches of thicket and heavier timber. Mag. Var. 7° 42′ to 10° 50′. Acreage, 23,045.72.

Holt. *T.* 103 *N.*, *R.* 9 *W.*

A prairie tract covers secs. 25, 35 and 36, and a portion of 31. With this exception, and the wet prairie within the river bluffs, this town is wooded. The Root river passes through sections 7, 8, 9, 3 and 2. Mag. Var. 5° 12′ (N. side of sec. 3) to 14° 51′ (N. side of sec. 5). Acreage, 23,046.70.

Arendahl T. 104 *N., R.* 9 *W.*

The prairie portion is in the northwest and centre. A belt of timber skirts along the northern boundary, and on the east unites with the timber of the Root river valley in the southeast. About one-half of the town is timbered. Mag. Var. 5° 21′ to 17°. (The former is on the south side of sec. 33, and the latter on the southwest part of the same section.) Acreage, 23,007.34.

Harmony. T. 101 *N., R.* 10 *W.*

This town is represented as all wooded except about one section, covering parts of 14, 13, 23 and 24; and about half a section covering contiguous portions of secs. 18 and 19. (There seems to be an error in the plat of this town. The central portion is probably prairie.) Mag. Var. 9° 25′ to 12°. Acreage, 23,013.72.

Preston. T. 102 *N., R.* 10 *W.*

This town is greatly diversified with frequent changes from prairie to thicket and timber. The Root river, which enters it in section 6, soon leaves it on section 5, but by its deeply eroded valley has brought in a marked diversity of surface, accompanied by more or less timber. Mag. Var. 9° 17′ to 12° 12′. Acreage, 23,008.29.

Carrollton. T. 103 *N., R.* 10 *W.*

There is but little prairie in this town. The only parts so represented being in sections 35 and 36, and the northern portion of section 6. A tract of heavy timber occurs in the northwest, sections 7 and 8. The valley of the Root River, though very rough, is not always wooded. Mag. Var. 6° 12′ to 13° 45′. Acreage, 23,026.34.

Pilot Mound. T. 104 *N., R.* 10 *W.*

In the northeastern part there is a prairie tract and also in the northwestern, but the greater portion is represented as wooded, or covered with brush and thickets. The Root river, which crosses it in a southeasterly direction, brings in a deep valley of erosion, with rock-bound bluffs several hundred feet high. Var. 8° 51′ to 13° 45′. Acreage, 22,998.57.

Bristol. *T.* 101 *N.*, *R.* 11 *W.*

This town consists of prairie and thickets, a belt of the former, widening to 5 miles toward the west, crossing it from east to west. Mag. Var. 10° 20′ to 12° 40′. Acreage, 23,026.98.

Carimona. *T.* 102 *N.*, *R.* 11 *W.*

There is an area of prairie in the southwestern corner of this town, but the most of the town is covered with sparse timber, with patches of heavy timber. It has a great many "sink holes." Mag. Var. 8° 30′ to 12° 15′. Acreage, 23,071.37.

Fountain. *T.* 103 *N.*, *R.* 11 *W.*

A great many "sink holes" also are found in this town. It has small patches of timber or oak thickets, scatterred over the whole area, and a considerable heavy timber along the streams. Watson's creek crossing it from west to east, is the cause of a considerable diversity of surface. Var. 8° 5′ to 11° 6′. Acreage, 23,103.77.

Chatfield. *T.* 104 *N.*, *R.* 11 *W.*

The North Branch of Root river, with its various tributaries, causes a rough and sometimes rocky character of surface to prevail in much of this town. It has but little real prairie, though there are openings in the thickets and oak bushes that are without timber. Mag. Var. 7° 51′ to 11° 2′. Acreage, 23,022.63.

York. *T.* 101 *N.*, *R.* 12 *W.*

A tract of wood and thicket crosses this town N. and S., about two miles wide, east of the center. The rest is prairie. Mag. Var. 9° 49′ to 11° 43′. Acreage, 23,076.54.

Forestville. *T.* 102 *N.*, *R.* 12 *W.*

The central part of this town is covered with timber and small oaks and aspens. It has a tract of prairie in the N. W. and in the S., both together covering about six sections. It abounds in sink holes. Mag. Var. 9° 41′ to 12° 2′. Acreage, 23,205.28.

Fillmore. *T.* 103 *N.*, *R.* 12 *W.*

There is a region of heavy timber west of the Middle Branch of Root river, in this town. The rest is prairie interspersed with thickets and patches of oak brush and aspen. Mag. Var. 8° 40′ to 11° 42′. Acreage, 23,032.33.

Jordan. *T.* 104 *N.*, *R.* 12 *W.*

The greater portion of this town is covered with heavy timber, the only noteworthy region of prairie being in the northwestern corner, covering secs. 6, 7 and 18, and parts of 19, 20, 17, 8 and 5. Mag. Var. 9° 42′ to 12°. Acreage, 23,035.51.

Beaver. *T.* 101 *N.*, *R.* 13 *W.*

A strip of timber accompanies the valley of Slough Creek, across the whole of this town, from section 6 to section 35, and the rest is of prairie, with several narrow sloughs, running generally north and south. Mag. Var. 8° 59′ to 11° 15′. Acreage, 23,072.50.

Bloomfield. *T.* 102 *N.*, *R.* 13 *W.*

There is an irregular area of timber and oak brush in the eastern and central part of this town, accompanying and spreading northward from the valley of the South Branch of Root river, but about two-thirds of the whole is of prairie, with a few sloughs in the eastern part. Mag. Var. 9° 8′ to 12°. Acreage, 23,013.96.

Spring Valley. *T.* 103 *N.*, *R.* 13 *W.*

There is a belt of prairie covering the southern tier of sections, including parts of 29, 28 and 27. The rest is sparsely or heavily timbered. Var. 10° 15′ to 13°. Acreage, 23,063.86.

Sumner. *T.* 104 *N.*, *R.* 13 *W.*

The southeastern part of this town is wooded, but more than one-half is of prairie, and flat. Mag. Var. 8° 25′ to 13° 15′. Acreage, 22,915.69.

Soil and Timber.

The soil of the county is generally very fertile. The immediate surface is a loam. This varies in color and composition, as well as in origin. That portion of the county covered with the northern drift has primarily a drift soil, which consists of gravelly clay. Where this forms the immediate surface, which is the case only on knolls and on the brows of the river bluffs, it affords a soil of an ashen color, if dry. In timbered belts it is more stony, or gravelly. In the open prairies, and in low grounds, it is covered with a loam. This is believed to have resulted from the natural decomposition of the coarse materials of the drift, under the calcining influence of the prairie fires, and the frosts of ages. It has never been seen stratified, or arranged with any regularity that would indicate its having been deposited either by standing or running water. In most cases, especially on the open prairie, it is nearly black. As it is mingled with the drift clay, it becomes lighter colored. In the low grounds it is much thicker, and also of a black color. Overlapping the drift area, in a belt about five miles wide, is a soil formed by the mingling of the loess loam with the drift. The loess loam is later than the glacial drift, and in the process of deposition it is modified by contact with the drift clay. The loess loam is indistinctly stratified, though it usually appears massive, and consists of fine, often clayey, sediment. The soil derived from it, usually sandy and light colored, or rusty, is sometimes so clayey as to make, when wet, a fine and very slippery mud. The soil derived distinctively from the loess loam covers at least one-half of the county, and is supposed to extend to the Mississippi river. It makes a rich and apparently a strong soil, as it supports a cropping of wheat from year to year. It is impossible to define its western limit. If it were derived from a long-standing inland lake, some beach lines would be found indicating its western boundary. No beach lines have been found. That it was deposited from standing water can hardly be questioned. It thins out westwardly gradually, passing through a confused or mixed condition, resulting from the mingling of the drift materials with the sediment, or by its overlapping the drift. While the essentially loess loam soil, of the eastern part of the county, can be distinguished easily from the drift soil of the western, no line of demarkation separating them has been noticed. A line drawn from the southeast corner of Bristol to the northeast corner of Jordan would roughly set off the area that has a distinctively loess loam soil. West of that is a belt five or six miles wide, in which the loess loam soil mingles with the drift soil. The rest of the county toward

the west is occupied with a distinctively drift soil, or drift loam soil.

The following list embraces such native trees and shrubs as were seen in the survey of the county. The trees are arranged in the estimated order of frequency. The area covered by native timber is steadily increasing:

Burr Oak. Quercus macrocarpa. *Michx.*

Red Oak. Quercus rubra. *L.* (?) [This is the oak that is abundant as underbrush, and small trees. It often forms thickets skirting the outlines of a prairie.]

Aspen. Populus tremuloides. *Michx.* [Generally small, and on the borders of prairies.]

White Oak. Quercus alba. *L.* [Common in the timber in Spring Valley and Jordan townships, and generally along the valleys of the principal streams.]

Wild Plum. Prunus Americana. *Marsh.*

Great-toothed Poplar. Populus grandidentata. *Michx.* [Very frequently mistaken for the American Aspen]

American Elm. Ulmus Americana. (*Pl. Clayt.*) *Willd.*

Bass. Tilia Americana. *L.*

White Ash. Fraxinus Americana. *L.*

American Crab. Pyrus coronaria. *L.* [Common along the margins of prairies and in open valleys.]

Iron Wood. Ostrya Virginica. *Willd.*

Red Maple. Acer rubrum. *L.*

Sugar Maple. Acer saccharinum. *Wang.* [Common in the heavy timber in Spring Valley and Jordan township.]

Cottonwood. Populus monilifera. *Ait.*

Black Cherry. Prunus serotina. *Ehr.* [Trees generally small.]

Black Oak. Quercus tinctoria. *Bart.* (?) [Found in the heavy timber in the northwestern portion of the county.

Bitternut, Carya amara. *Nutt.*

Butternut. Juglans cinerea. *L.* [Seen most abundant in the heavy timber in the northwestern part of the county.]

Wild Red Cherry. Prunus Pennsylvanica *L.*

Thorn Apple. Crataegus coccinea. *L.*

Cockspur Thorn. Crataegus Crus-galli. *L.*

White Birch. Betula alba. Var. populifolia. *Spach.* (?) [Trees small; generally on stony soil, or along rocky river banks.]

Black Walnut. Juglans nigra. *L.* [In the heavy timber of the northwestern part of the county.]

Box Elder. Negundo aceroides. *Mœnch.*

Small Cedar. Juniperus Sabina, *L.* Var. procumbens, *Pursh.*(?) [Along the rocky river bluffs.]

White Pine. Pinus Strobus. *L.* An occasional large tree is seen along the river bluffs; but the most of it, suitable for lumber, has been cut.

Water Beech. Carpinus Americana. *Michx.*

Shag-bark Hickory. Carya alba. *Nutt.* [Seen in the valley of Root river, and in the tributary gorges at Rushford.]
Smooth Sumac. Rhus glabra. *L.*
Cornel. Cornus paniculata. *L'Her.*
Cornel. Cornus circinata. *L'Her.*
Wolfberry. Symphoricarpus occidentalis. *R. Br.*
American Woodbine. Lonicera grata. *Ait.*
Juneberry. Amelanchier Canadensis. *Torr. and Gray.*
Hazelnut. Corylus Americana. *Walt.*
High Blackberry. Rubus villosus. *Ait.*
Red Rasperry. Rubus strigosus. *Michx.*
Black Raspberry. Rubus occidentalis. *L.*
Dwarf Wild Rose. Rosa lucida. *Ehr.*
Pipe Vine. Aristolochia Sipho. *L'Her.* (?)
Grape. Vitis cordifolia. *Michx.*
Virginia Creeper. Ampelopsis quinquefolia. *Michx.*
Nine Bark. Spiraea opulifolia. *L.*
Sheep-berry. Viburnum Lentago, *L.*
Staghorn Sumac. Rhus typhina. *L.* (Rare.)
Bittersweet. Celastrus scandens. *L.*
Rose. Rosa blanda. *Ait.*

The Geological Structure.

The rocks of the county belong to the Devonian and to the Upper and Lower Silurian ages. The Cretaceous also appears in Sumner township, in the extreme northwestern corner of the county. They occur as arranged in the following order, with their approximate thicknesses:

1. Cretaceous. Thickness unknown, perhaps 100 feet, lying unconformably on the older rocks.
2. Upper Devonian. Hamilton. } ....100 feet. ?
3. Lower Devonian. Corniferous.(?) }
4. Niagara of the Upper Silurian........................200–250 feet.
5. Maquoketa (Cincinnati) of the Lower Silurian..........*75–100 feet.
6. Galena, of the Lower Silurian........................ 75–100 feet.
7. Trenton, of the Lower Silurian........................ 160 feet.
8. St. Peter, of the Lower Silurian .... 122 feet.
9. Shakopee, } Lower Magnesian of the Lower Silurian, { 75 feet.
10. Jordan, } { 25–40 feet.
11. St. Lawrence, } { 200 feet.
12. St. Croix, of the Lower Silurian, exposed.................. 375 feet.

With the exception of the Cretaceous these formations have a strike across the county northwest and southeast. They have a

* Geology of Wisconsin, Vol. 1, p. 181.

gentle dip, at least theoretically, toward the southwest, though no general dip is perceptible. The oldest rock in the county is the St. Croix sandstone, which appears in the northeastern corner of the county. The latest, except the Cretaceous, is the Devonian, in the southwestern part of the county. The areas of outcrop are shown by the colored map of the county accompanying this report. The boundary between the Trenton and the St. Peter is the most accurately defined, owing to the terrace which marks it. The boundary between the St. Peter and Shakopee it is impossible to ascertain certainly, because of the universality of the loam, which acts, in that respect, just the same as a heavy drift deposit, and also because of the persistency of the Shakopee compared to that of the St. Peter. When the friable rock is below a hard and persistent one, as the St. Peter below the Trenton, the boundary between them can be traced out easily by the resulting topography; but when the soft one is uppermost it wedges out imperceptibly under the loam, or drift, and one cannot say when it is all gone. In the western part of the county the boundary lines are all obscured by the prevalence of the drift. The Maquoketa shales have not been seen in the county. They are visible in the bluffs of the Upper Iowa River, at Lime Springs, about three miles south of the State line, and very probably continue through Fillmore county, in the strike of the Lower Silurian.

The St. Croix Sandstone.

The area of the St. Croix sandstone is small. It only occupies the lower portion of the river bluffs, and the bottom land included between them, from the county line, near Rushford, to near Lanesboro. This bottom land is sometimes two miles, or more, in width, but it is an alluvial deposit, and never reveals the rock. The only visible outcrops are in the slopes of the bluffs. This sandstone also enters the county, in a similar manner, in the valley of the South Branch of Root river, and extends about three miles west of the county line.

Its *general lithological character* is all that can be learned of this rock from its exposures in Fillmore county. The opportunity for examination is very unfavorable. The bluffs, over the interval occupied by it, are almost universally turfed, and a heavy talus rises nearly or quite to the lower level of the St. Lawrence limestone. It is in general a light colored sandstone, with alternations of limestone, and some shale, in its upper portions. The sandstone layers

crumble easily. Some of the beds are of a very coarse grain, but the quartz is generally white, almost transparent. The limestone layers are like that of the St. Lawrence, and contain a few fossils, none of which have been studied yet with care sufficient for reliable specific identification. At Whalen, about 95 feet of the St. Croix sandstone are included in the lower slopes of the bluffs. This thickness of bedding disappears below the river level before reaching Lanesboro. At Rushford, the sandstone, and talus which is supposed to consist mainly of sandstone, rise 375 feet above the river. Near the upper portion of the sandstone, a conspicuous terrace or line of frequent exposure, producing a shoulder, may be seen along the creek in entering Rushford from the south.

The St. Lawrence Limestone.

This is the lowest portion of the *Lower Magnesian* formation of Dr. D. D. Owen. In the annual report for 1873, the geology of the Minnesota Valley is given. It is there announced that the great formation to which the name *Lower Magnesian* has been applied, consists of three distinct members—two limestones separated by a sandstone—and the names of the localities where these members have their characteristic outcrops, in that valley, were applied to distinguish them, as they will play an important part in working out the detailed geology of the eastern portion of the state. Since the publication of that report, a similar subdivision of the Lower Magnesian has been discovered in the state of Wisconsin, and it is announced in the American Journal of Science and Arts, for June, 1875, by Prof. R. Irving, of the University of Wisconsin. The county of Fillmore lies intermediate between the two points at which this similar alternation of parts in the Lower Magnesian has been identified, and may throw some light on the question of the parallelism of these principal members. Fillmore county is separated from the Mississippi river by one county, Houston, which is 24 miles in width, east and west, and borders on the state of Iowa.

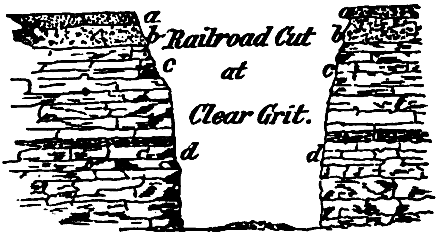
The *area* of this limestone is embraced in that which is, in general, assigned to the Lower Magnesian on the accompanying map. Along the river bluffs, nearly to Rushford, it is found only in the lower portion of the limestone belt, as the Jordan sandstone and Shakopee limestone are both preserved, and overlie it; but toward Rushford this limestone begins to be the only one that is found in the bluffs, the other members of the lower Magnesian having a strike across the country some miles in either direction away from the immediate valley. There are places, even further east still,

where the overlying Jordan and Shakopee are preserved and appear in the tops of the river bluffs. The St. Lawrence extends in the bluffs of the Root river to some distance above Isinours' Station, and nearly to the lower mill at Preston. The valley of Watson's creek at Isinours' Station is cut about 25 feet into the St. Lawrence. At Lanesboro the amount of the St. Lawrence visible is about 195 feet. At Whalen 155 feet are seen in the upper portion of Whalen's bluff. At Rushford the uppermost 190 feet of the bluffs are of the St. Lawrence. The thickness of the formation is not far from 200 feet. It constitutes the principal portion of the Lower Magnesian.

The St. Lawrence, in Fillmore county, is a *dolomitic limestone*, with some of its layers distinctly arenaceous, and stained with green sand. In general, its bedding is regular and evident, but there is a thickness of about 15 feet near the bottom of the formation in which the bedding is confused, or the layers are lost horizontally. Below this confused bedding are, however, about 25 feet of regular beds, which have a fine even grain, and though not plainly arenaceous, yet have a very fine grit. On fresh surfaces it is of a buff color, varying to cream color. The upper portion abounds in patches of white calcite. There are also in the upper portion spots that show thin, concentric, though wavy, laminations, as if from concretionary forces, or the result of silicified masses of *foraminifers*, reminding the observer of the laminated masses of limestone from the *Laurentian* containing the *Eozoon Canadense* of Dr. Dawson. Though the most of the rock of this formation is vesicular, often coarsely so, it is much used for building, for which it furnishes both large blocks for the heaviest masonry, and fine-grained stone that can be cut into delicate forms. When cut for window caps or sills the cut surfaces are nearly white. The bedding varies in thickness from two or three inches to two or three feet, and sometimes embraces thin beds of shaly, light-colored, fine-grained rock that is useless for all purposes.

At Clear Grit Mills, in the valley of Root river, the St. Lawrence begins to show a continious line of bare rock, in the river bluffs, running along the lower slopes, and causes a shoulder or terrace in the general descent. A quarry near the mill-dam shows about 15 feet of even layers. Above these are the layers represented in the railroad cut near that place. These are light-colored, dolomitic, vesicular, abounding in patches of calcite with some chert, and siliceous concretions, the latter sometimes covered with limonite pseudomorphous after pyrite. The annexed profile exhibits the cut and the materials exposed.

Fig 2.



a.—Loess Loam, 8 feet, red.
b.—Drift Gravel, 4 feet, red.
c. Jordan Sandstone, 16 feet, red.
d. St Lawrence Limestone, 30 feet.

At Whalen the St. Lawrence is finely exposed in the bluff that stands in the valley about half a mile below the village. It has here been considerably quarried, and furnishes a very good stone for buildings. It lies in even layers, which are easily broken into desirable size and shape, furnishing a good cut-stone of close grain, without openings. Of the 155 feet that here overlie the St. Croix sandstone, only the lower portion is well exposed. The exposed layers are separated from those seen at the quarry at Clear Grit by an interval of 50 feet. They consist of the following parts, aggregating 60 feet:

1. Slope, hid by turf, (St. Lawrence).......................... 95 feet.
2. Heavy beds, even-grained, vesicular, the best general building stone.. 20 feet.
3. Bedding confused, not evident, lenticular.................... 15 feet.
4. Fine grit, regular beds, dolomitic.......................... 20 feet
5. Hard arenaceous, projecting, fossiliferous with the remains of trilobites.. 5 feet.

At Lanesboro the St. Lawrence has been used in the construction of the principal buildings. The quarries are owned by the Lanesboro Company. The stone presents the usual characters, but has associated masses of pyrite, largely converted to limonite, showing octahedral forms of crystals, with combinations. In some of the cherty nodules, are found small orthorhombic crystals of hydrated iron peroxide, formed by the conversion of marcasite into limonite. This iron ore is quite plentiful, but seems not to be a native of the rock. It embraces crag and bog-ore deposits, and is referable to the drift period. (See under *drift*.)

The Jordan Sandstone.

This sandstone, lying next above the St. Lawrence limestone, is not so frequently seen along the river bluffs. It is most commonly embraced in that interval of slope that comes between the two lines of limestone outcrop, and which is mostly turfed over, as in the bluffs at Lanesboro, and at points between Preston and Lanesboro. Further down the river, where the strike of the Shakopee runs back from the river a few miles on either side of the valley, it occupies the undulating surface between the immediate river bluffs and the boundary of the Shakopee, as at Rushford. This sandstone, in the Minnesota valley, has been mistaken for the Potsdam, the overlying Shakopee being supposed to be the lower portion of the lower Magnesian. (*Owen's Geological Survey of Wisconsin, Iowa, and Minnesota*, pp. 481–495. See, also, Prof. James Hall's "*Notes on the Geology of some portions of Minnesota, from St. Paul to the Western part of the State*," 1865.)

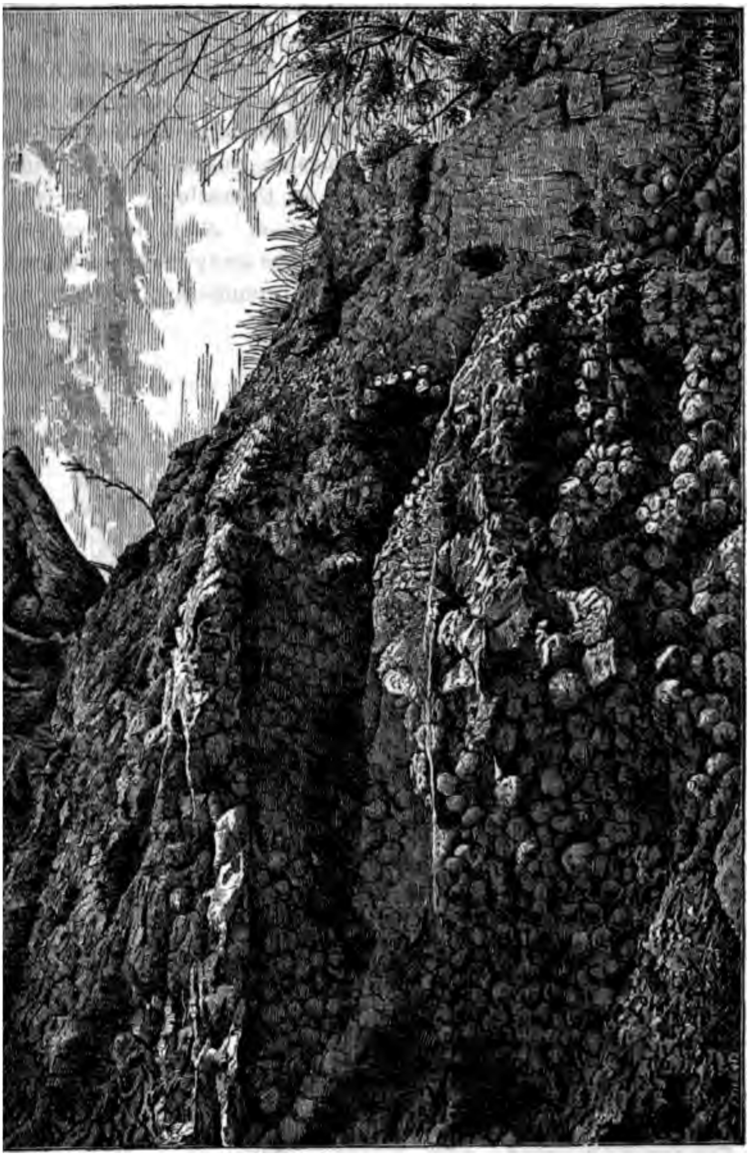
In Fillmore county the thickness of the Jordan is not so great as it is in the Minnesota valley. It seems to vary from 25 feet to 40 feet. At Mankato, in Blue Earth county, it is fully fifty feet thick. It is uniformly a coarse grained, quartzose, crumbling and light colored sandstone. It is sometimes locally stained with iron from surface water, when it presents a reddish or rusty color, and is apt to be much harder. It has in such cases a shell or thin coating of harder rock, about half an inch in thickness, on the weathered surfaces, on penetrating which the grains are loosely cemented, and even crumbling. In other places, it presents internally a streaked appearance, due to the stoppage of iron filtering through its strata. No fossils have been found in it.

One of the best exposures for examining this sandstone may be seen at Preston, where it rises 25 feet above the level of the river opposite the stone mill, and is surmounted by about 35 feet of the Shakopee limestone. The bluff itself rises about 95 feet above the river, but the contents of the upper portion, though probably of the Shakopee, are not certainly known. The loam covers it. The bedding of the stone here is regular, though in some places a little wavy, and is of all thicknesses, from a foot to three or four inches.

At Lanesboro the Jordan exhibits, near the top, a finely concretionary structure. The balls vary from a few inches to nearly a foot in diameter. Some of them are elongated, and several are frequently united. The rock itself is generably friable, and crumbles out, leaving the concretionary shapes visible. They are often

loosened, and roll down the bluff. They lie in approximate layers for a thickness of four or five feet. Some of them are pendant from the projecting shelf, and stud the whole under surface. They are generally spherical, but when they are lengthened perpendicularly, they show the original lamination that ran through the rock, in the form of rings and furrows. The accompanying view, engraved from a photograph by Andrew Ellickson, of Lanesboro, gives an imperfect representation of this portion of the bluff. This view was taken near the mill dam, above the railroad cut.

FIG. 3.



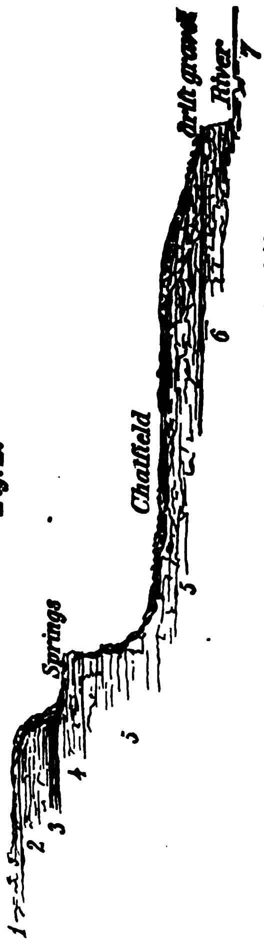
Concretions in the Jordan Sandstone at Lanesboro.

At Clear Grit the Jordan is 25 feet thick, and is exceedingly ferruginous. At Lanesboro it is about 40 feet thick.

The Shakopee Limestone.

This is the uppermost member of the Lower Magnesian, and is so named from the village of Shakopee, in Scott county, on the Minnesota river, where it was first identified as a distinct and entire member of the great Lower Magnesian Formation. In Fillmore county it is more frequently seen along the valley of Root river and its tributaries than any other formation. As it lies between two sandstones, each of which easily crumbles away under the operations of the elements, it is made to have a prominent position in giving form to valleys and river bluffs. The North Branch of Root river enters on it about six miles northwest of Chatfield, in Olmsted county; the Middle Branch near the town line between Chatfield and Jordan, and the South Branch but a short distance below Forestville. South Root river strikes it near Henry, in Amherst township. Thus, throughout about two-thirds of the county, it is the constant companion of the traveler along the river valleys, and it meets him often in the uplands, and in the valleys of little creeks. Its effect on the topography is to render the valleys narrow, rocky and abrupt. Within the general area of the St. Peter sandstone and the Trenton limestone, it produces a shoulder in the descent from the uplands to the valley. The following diagram, taken at Chatfield on the northern boundary of the county, illustrates in general the effect of this limestone in producing a terrace along the lower slopes of the river bluffs, within the general Trenton area.

Fig. 4.



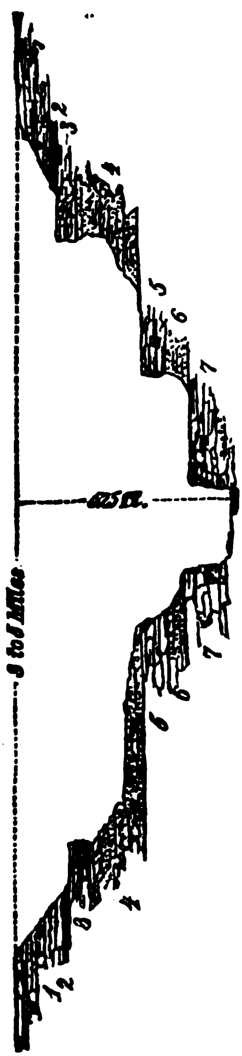
Profile of the north side of the River Valley at Chatfield.

EXPLANATION:—1. Loam..........6–10 feet. 2. Upper Trenton..........20–60 feet. 3. Green Shale..........15 feet. 4. Lower Trenton..........20 feet. 5. St. Peter..........122 feet. 6. Shakopee..........30 feet. 7. Flood plain.

The descent from the general

level of the country at Chatfield (No. 1) to the river (No. 7) is about 222 feet, of which about 30 feet are of the Shakopee, the descent from the Shakopee to the river being at the river. The broad terrace on which Chatfield stands is constituted of the Shakopee overlain by irregular thicknesses of the St. Peter, with some drift and loam. The lithology of the Shakopee is very much the same in Fillmore county as it has been described in former reports at Mankato and Shakopee, in the Minnesota Valley. It is very similar to the St. Lawrence, with much less of green sand. It contains at Chatfield considerable disseminated sand, and nodules of calcite. The calcite is sometimes purely transparent, so as to exhibit the double refraction of Iceland spar, parting into large rhombohedrons, but the most of it is opaque. It is sometimes interspersed with sand grains taken up in the process of crystallization. These are so abundant as to make, of some crystalline masses, a sandstone which is then nodular and hard, with warty projections.

FIG. 5.



General Profile Section of the Valley of Root river.

EXPLANATION:—1. Upper Trenton. 2. Green Shales. 3. Lower Trenton. 4. St. Peter. 5. Shakopee. 6. Jordan. 7. St. Lawrence.

At Parsley's Ford, centre of section 15, Chatfield, a bridge is being built over the river, the abutments being of the Shakopee stone taken out near the ford, on Mrs. Doyle's land. At the ford the river is on the Jordan sandstone. There has been considerable stone cut off the bluffs, in the Shakopee, for use in the railroad bridge near the same place, and laid up in heavy blocks; but much of the Shakopee is in irregular and thin layers, unfit for such use.

At almost any point east of Chatfield and Carimona, the Shakopee can be seen by one crossing the valley of Root river, exhibiting its

peculiar tendency to narrow the valley, and forming a conspicuous bench or shoulder. The following diagram of a general profile section of the valley, illustrates its form at points between Preston and Lanesboro; also between Chatfield and Lanesboro, along the North Branch. At Preston the rocks show a dip to the south.

At Isinours' Station the battlements of rock that enclose the valley, rising about 30 feet above the water, are of the Shakopee. There is an undulating ascent thence over the St. Peter to near the Trenton terrace, which rises nearly perpendicular about 50 feet. Beyond this is a flat, running sometimes but 8 or 10 rods, but not infrequently a quarter of a mile, when a further gradual ascent begins, covering the Green Shales and the Upper Trenton. This last ascent, with the loam that here covers the country, generally makes about 175 feet.

At Carimona, the Shakopee is visible in the banks of the river, rising 25 or 30 feet. Its average thickness is about 75 feet.

The St. Peter Sandstone.

The thickness of this well-known formation in Fillmore county does not vary much from its reported thickness in the central portion of the state. It has been taken at 125 feet. At Chatfield, it measures, by aneroid, 122 feet. In lithological characters it is also the same, consisting of clean white sand that easily crumbles. Near Fountain, an exposed section near the top of the formation, afforded fragments of an unknown species of *Lingulepis*, the first and only fossil of any kind that has ever been found in this rock. The following section was taken at this place. It includes the overlying lower Trenton, and the green shales, as seen at the quarry of Mr. Joseph Taylor, section 13, Fountain.

Section Near Fountain—Quarry of Joseph Taylor.

No. 1. Green shale, mixed with fragments of limestone that are eminently fossiliferous .... seen 3 feet.

No. 2. Limestone, of a bluish-gray color, in beds from four to six inches thick, free from shale, though the layers are sometimes thinly separated by shaly partings... ..... 10 feet.

No. 3. Arenaceous and ferruginous shale, alternating horizontally with firmly cemented patches of sandstone......... 2 feet.

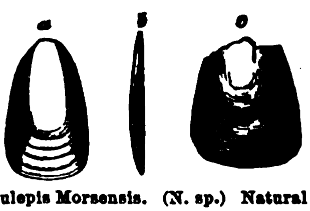
No. 4. Massive, coarse sand; white, except where iron stained, containing irony quartzite pebbles, and fragile remains of bivalves...................................... 6 feet.

No. 5. Green shale, with some arenaceous and calcareous laminations... 3 feet.
No. 6. Cemented sandstone, the cement being shale and lime, forming when the bluff is weathered, the floor of a bench 1 foot.
No. 7. White sand, in beds that are about one foot thick, and horizontal... 6 feet.
No. 8. A course in the sandstone more firmly cemented, forming another table, but less persistent than No. 6.......... 1 foot.
No. 8. Massive sandstone, in some places showing an oblique lamination.....................................seen 6 feet.

The Southern Minnesota railroad here enters on its descent to the Root river valley.

The species of *Lingulepis* mentioned is found in No. 4 of the foregoing section. The remains are exceedingly fragile, and as the grains of sand in which they are embraced are feebly cemented together, it is nearly impossible to transport, or even to handle them without their falling to pieces. These fragments, for no entire specimens were obtained, are arranged promiscuously in the coarse sand, and are all confined within three feet of the top of No. 4. They seem to have suffered the attrition and friction incident to coarse sedimentary transportation. They dispel the idea, which has been suggested, of the possible chemical origin of the St. Peter sandstone, as an oceanic precipitate.

FIG. 6.



Lingulepis Morsensis. (N. sp.) Natural size.

Description.—Shell conical or elongate-conical, with anterior angles rounded; depressed; the apical angle not seen perfect; the front margin gently convex; sides nearly straight, but converging at an angle of about 26 degrees; greatest width is near the front and at a distance from the anterior margin of one-third the greatest width. The surface is smooth and shining, marked with very fine concentric striæ, visible especially in the anterior portion, and with more distant, dim undulations of growth. Entire length of the larger specimen seen (Fig. C.) about .85 inch; width .52 inch; length of the smaller (Fig. B.) .78 inch, width .45 inch. Color of the shell

Extensive working and burning of the upper Trenton into quicklime is carried on along Bear and Deer creeks, the banks of which are continuously rocky, rising perpendicularly from one to two hundred feet from the water, in Sumner and Spring Valley townships. These quarries are described under the head of *Economical Geology*.

Sometimes the Trenton shows, on freshly opened quarries, along the bluffs, almost a white color. This is particularly the case on north half of section 35, Sumner, where an opening in a long-weathered "hog's back" reveals a very light-colored limestone, in beds of about three inches, of a fine grain and compact texture; not much crystalline, and evidently impure with argillaceous and siliceous qualities.

The quarry of Mr. Joseph Taylor, section 13, Fountain, has been mentioned already under the head of the St. Peter sandstone, and the exposed section given. At this quarry very large cephalopods have been taken out, and some fragments of galena have been encountered, though the opening is in the lower Trenton.

The quarry of Mr. Enoch Winslow is on the same horizon as Mr. Taylor's. It is situated on the bank of Sugar Creek, S. W. ¼ sec. 4, Fountain. Another on the same horizon is that of John Johnson, 2 miles south of Fountain. The Trenton is also wrought at Forestville and near Carmiona, presenting no exceptional features. At Forestville it contains *Receptaculites* and *Strophomena*, and exposes a thickness of about 140 feet.

The Upper Trenton appears S. E. ¼ sec. 6, Forestville, along a little ravine, and is slightly opened by John Hipes. It also appears at other points between there and Spring Valley.

At Baldwins' Dam, sec. 21, Forestville, 130 feet of the Trenton are seen. No Galena visible, and no Green Shale.

S. E. ¼ sec. 30, Forestville. In some fragments thrown out in the digging of a well, can be seen a fine grained rock, resembling the fine shale seen in the race at De For's mill, which crumbles to pieces in the weather. It here lies below some heavy Galena beds, seen in the hills enclosing the valley, and contains doubtfully species of *Graptolites*, *Orthis*, and *Orthonota*.

At Granger, the Trenton only occupies the bluffs; but at two miles west of Granger, where the river enters the state for a short distance, the bluffs are high, and are made up of the Trenton, with a topping of fifteen or twenty feet of Galena.

Northwest quarter of section 36, Bristol. Hiram Andrews has a quarry in the Trenton, which alone occupies, at this place, the river banks, though the beds of the quarry are apparently in the upper

portion of the formation. The layers are thicker than usual, somewhat vesicular, and present some of the aspects of the Galena. The rock shows a slight dip to the south. Mr. Andrews has built a stone barn and stable.

The Galena Limestone.

The only separating horizon between the Trenton and Galena limestones is a lithological change in the rock. There is no unconformability between the layers of the formations, and there is no known difference of fossil contents. Near the upper portion of the Trenton occasional layers appear that are much more porous, and have a light buff color. They are also much heavier than the layers of the Trenton, reaching, after the change is fully established, a thickness of four or five feet. Mingled with these heavy magnesian layers are thinner layers of green shale. When these heavy magnesian beds are near the top of a bluff, they give it a roughness, but at the same time a persistence of outline which the thinner beds of the Trenton alone do not possess. This rock is generally sharply crystalline. It contains numerous cavities of irregular shape, some due to the weathering out of carious material, and some to the absorption of fossils It holds considerable masses of calcite, and sometimes lumps of galena, from which it has derived its name. Although the Galena limestone, near Dubuque, in Iowa, is stated by Prof. J. D. Whitney to be about 250 feet, (Geology of Wisconsin, vol. I, 172,) it enters Minnesota with a thickness much less than that. From all that can be seen of it in Fillmore county, it appears to be less than 100 feet thick. The Trenton, on the other hand, is given, by the same authority, at 70 feet average thickness, at Dubuque, while it has a thickness of 160 feet in Fillmore county.

The characters that distinguish the Galena are not constant. In Fillmore county the "lead fossil," *Receptaculites*, pervades the Trenton as low as the green shale, at least—although regarded as characteristic of the Galena; and the *Lingula quadrata*, also said by Prof. Whitney to not appear in the lead region, in the "blue" nor the "buff," is found throughout both. A very fine specimen was obtained, of the latter, at Mr. Taylor's quarry, near Fountain, from the lower Trenton, ("buff limestone" of Prof. Whitney,) and another from Chatfield, from the same horizon. Lithologically also the two formations appear to merge into one another. The compact, hard blue limestone, characteristic of the Trenton, gives place near the top of that formation, to a lighter colored, slightly vesicular, even grained. more heavily bedded rock, that is very useful for an orna-

ter section 36, where it has been opened, as at the other points named, and used for mortar. These are situated in an undulating tract, with some shrubs and trees. These sand beds are not regarded as belonging to the Cretaceous rock *in situ*, but as being copious local products, under drift agencies, of the Cretaceous. Sometimes they embrace lumps of clay, of a greenish color, like the Fort Benton, and sometimes they show oblique stratification. They are entirely uncemented, so as to be shoveled directly into the wagon. Another singular deposit, in the same manner referable to the immediate presence of the Cretaceous, occurs on the southwest quarter section 15, Bloomfield, land of Peter Peterson. Here a series of knolls, which embrace, indeed, that in which is Mr. Andrew McNee's white sand pit, and are covered with aspen and hazel brush, are found, many of them, to be composed of a beautiful, coarse gravel, the greater part being white, often limpid, quartz, the size of the pebbles varying from that of a pea to that of a hazelnut. On these knolls are a few northern drift boulders, and no doubt the gravel was also placed in the position it now occupies by the drift forces. This gravel, so remarkably homogeneous, like the white sand deposits mentioned, can only be referred to the immediate proximity of the lower Cretaceous. It could not have been far transported without being mixed with other rock material. It distinctly points to the existence of a coarse gravel or conglomerate in the lower Cretaceous, which has not yet been discovered. It indicates also the littoral nature of the Cretaceous beds from which it was derived.

There is still another indirect evidence of the existence of the Cretaceous in the western portion of Fillmore county. There are heavy deposits of limonite iron ore, bearing some unascertained relation to the Cretaceous, or to the drift found in the southwestern part of the county. In the Second Annual Report of the Survey mention was made of the occurrence at a number of places in the Minnesota Valley, and in that of the Blue Earth, of a coating of iron ore on the Lower Silurian rocks, where they are unconformably overlain by the Cretaceous. Dr. Shunard says of this: (*Owen's Geological Survey of Wisconsin*, *Iowa and Minnesota*, *page* 487.) "The nodules of iron ore have mostly a concentric structure, and appear to be of good quality. The superficial indications render it probable that this bed of iron ore may be both extensive and easily accessible." In Fillmore county a discovery was made by Mr. C. C. Temple, in digging a well near his sand pit, already described, and referred to the Cretaceous as its probable source, which throws

some light on the manner of occurrence of the limonite referred to. He testifies that *this bed of iron ore is at least thirty-six feet in thickness.* In his well, which is six feet circular at the top, he dug down about eighteen feet, when he reached rock, fragments thrown out revealing the Galena limestone. He describes the rock as occupying but about one-half of the diameter of the shaft he was digging, which afforded great quantities of soft limonite, or ochre. He drilled into the iron ore a depth of thirty-six feet. A number of wells in the vicinity of Etna, a few miles further southeast, also struck a similar iron ore. On section 36, Bloomfield, a great many loose pieces of porous limonite are found in the fields, having been plowed up in the soil. The county surveyor, Mr. J. Gregor, also found it impossible to lay out the quarter sections of that section in the usual manner, by the use of the magnetic needle, though the original United States surveyors record no unusual disturbance of the magnetic needle. Limonite iron ore is regarded usually as non-magnetic. In large quantities, near the surface, it seems to influence the magnetic currents. What relation this ore bears to the Cretaceous is not known, except that it has been found to overlie the Silurian rocks, or to cover their surfaces with a scale where the Cretaceous overlies them unconformably. Further and more minute observations in other places may reveal its real source and its value. The reader is referred to the Second Annual Report for an account of the *Cretaceous over the Lower Silurian* at Mankato, in the Valley of the Minnesota.

The Drift.

The drift presents some interesting features in Fillmore county The western limit of that well-known tract denominated *The Driftless Area*, by Prof. J. D. Whitney, crosses this county. This boundary is not well-defined. There is a very conspicuous absence of the bluish clay, and the northern boulders that distinguish the true northern drift sheet of counties further west and north, throughout the eastern two-thirds of the county; the boundary line running approximately, from the southeast corner of Bristol township to the northeast corner of Jordan. West of that line, which is modified, in its course, by valleys and uplands, is a belt of five or six miles in width, which is characterized by an overlapping of the loess loam on the thinning out edge of the drift sheet. This belt is characterized further by peculiar local modifications of the materials of the drift, due to the underlying rock, as mentioned under

the head of *Cretaceous*. West of this belt the true drift becomes prevalent, consisting of clay, with many boulders.

That tract which is regarded as driftless,* is, so far as Fillmore county is concerned, not without some evidences of having been subjected, at some time, to a force similar to that which is supposed to have deposited the great drift-sheet of the northwest. There are isolated patches of gravel, with small stones, sometimes cemented into a crag, which have been noted in Fillmore county, scattered sparingly over the eastern part of the county, as the following field minutes will show:

Drift pebbles are in the street, north of the schoolhouse, southwest quarter section 22, Amherst.

Drift occurs in the form of gravel and boulders, some of them a foot in diameter, southwest quarter section 4, Fountain, on the east bank of Sugar Creek, in the road; seen in going east from the quarry of Enoch Winslow. At Fountain village there is said to be no drift between the loess loam and the rock.

A little drift may be seen at the Tunnel mills, section 34, Sumner.

There is a little fine drift visible along the road, southeast quarter section 25, Sumner.

At Chatfield there is some gravelly drift, with small boulders, visible in the street, near the millrace.

Drift, with pebbles and stones, appears about a mile south of Clear Grit, on the Shakopee terrace along the highway.

Also on the road to Carimona, near Preston.

About midway between Preston and Carimona, a wash by the roadside revealed—

Loam	8 feet.
Gravelly, red loam	3 feet.

With no distinct separation, a few small boulders lying in the water course below.

At Carimona a thin layer of drift is usually found under the loam.

The same is true at Forestville.

At Spring Valley the drift is so prevalent that the surface of the country is smooth, and has a lighter colored soil, with much more clay. There are but few stones or gravelly patches. The loess loam is hardly noticeable. One large boulder lies at the street corner, half a mile south of the corporate limits.

Between Baldwin's mill, section 21, Forestville, and the state line, due south, the country is one of drift prairie, nearly the whole distance, with stones and boulders, some of the latter pretty large.

At Ætna, section 36, Bloomfield, among a variety of stones pertaining to the drift, may be seen an occasional one that is *glaciated*.

* J. D. Whitney, Geology of Wisconsin, Vol. 1, pages 114-139.

At Lime Springs and Foreston, a few miles south of the state line, on the Upper Iowa river, the drift is abundant.

At Granger there is a light drift, and also where the road turns north to Preston, northeast quarter section 36, Bristol; but it becomes lighter still or entirely invisible, in traveling to Preston. In its place a heavy, rich loam, rather clayey, covers the country, and smooths it off almost as effectually as if drift-covered. A well, being dug about five miles south of Preston, on the high Trenton area, passes through this loam eighteen feet before striking the rock.

The drift is very thin at Lenora, if not entirely wanting.

About four miles southeast of Preston a large green, dioritic boulder may be seen lying in the loess loam, in the road, and a red quartzose pebble. The pebbles that appear in gullies by the roadside, in the loam area, are generally of chert, from the rock of the locality. It cannot be ascertained whether this dioritic boulder lies on other drift deposits, but it is surrounded laterally only by the loam.

At Elliota is a thin drift, in the form of pebbles, the largest being three or four inches in diameter. Thence northeastward to Newburg nothing but the yellow loam is observable. Between Newburg and Riceford, situated on the western edge of Houston county, no northern drift is visible; but at Riceford, which lies in a deep and narrow gorge, a few drift pebbles occur in the street.

About the center of sec. 29, Holt, is a deposit of drift gravel. It may be seen in descending the hill northward, just before the road forks to Whalen and Lanesboro. It is considerably cemented by lime, forming a crag, large lumps of which, some 18 or 20 inches thick, have been used for embankment on the lower side of the road. In some parts it is quite fine, and useful for mortar, for which it has been hauled away. It is at least ten feet thick.

There are boulders in the valley of Duxbury creek, sec. 28, Preston.

Sec. 19, Pilot Mound. In the road going to the river from the south, are a lot of boulders and other drift. The same can be seen on the north side, going up from the ford. The deposit seems to be five or six feet thick, gradually mingling with, and finally becoming replaced by the loess loam.

Drift gravel and stones are seen along the road in going down the hill to Isinours, from Preston.

Drift pebbles and clay occur at the crossing of Watson's creek, on the direct road between Fountain and Preston, and on the terrace of the Shakopee limestone, a quarter of a mile south of the creek.

Boulders are seen at Spring Valley, and on Mr. Kleckler's farm, two and a half miles east of Spring Valley.

An occasional boulder is seen in the river valley at Geiner's Mill, sec. 31, Jordan, but the most of the surface covering on the rock, in the high prairie region, seems to be of loess loam.

East of Highland P. O., in Holt township, sec. 36, is a conspicuous deposit of drift, exposed in the road, in the form of a stony gravel. It lies on the brow of the Shakopee terrace.

It is noticeable that in nearly every instance where drift pebbles

occur in the region known as driftless, they lie on or are very near an outcrop of firm rock. They frequent the brows of the terrace formed by the Shakopee limestone. The above named localities are nearly all embraced within the boundaries of the driftless tract, as already defined in Fillmore county. These patches of northern drift present the appearance of greater age than the drift of the western portion of the county, and are believed to belong to a glacial epoch that preceded the epoch that produced the great drift sheet of the northwest. An "interglacial epoch" separated them. It was probably during that interglacial epoch that grew the peat and coniferous vegetation that has been found in considerable abundance embraced within the great drift sheet, (or at least below fifty feet of drift materials) round its outer margin, as mentioned already in a report on Mower county, and as further demonstrated in Fillmore county. It is this older drift that is covered deeply by the loess loam, and *it is within the loam-covered portion of the county that true river terraces, of alluvial composition, are found.* (Compare *Geology of Ohio*, *Vol. II.*, *Report on Delaware County.*)

Ancient Peat and Vegetation in the Drift Deposits.

Owing to the great geological interest connected with the discovery made last year of a peaty bed within the drift deposits of Mower county, a careful search was made in the survey of Fillmore county for further information concerning its origin and exact relations.* There were found to be quite a number of places in the western portion of the county where farmers, in digging wells, had struck this bed of vegetation. No opportunity has been afforded to make a personal inspection of this bed, and owing to the indefiniteness of the information derivable from the farmers themselves, and its contrariety, it is thought best to give only the statements of Mr. Calvin E. Huntley, of Spring Valley, a professional well-driller. Throughout the whole of the county there is much difficulty in obtaining ready water for farm and domestic use, and a great many wells are drilled deeply into the rock. This is owing to the canoned character of the rock surface, both within the drift area and the loam-covered portion. These canons serve as subterranean drains, though they are generally filled with drift in the western part of the county. Mr. Huntley furnished the following facts

* For further information on the subject of vegetation in the drift deposits of the northwest, the reader is referred to a paper by the writer in the Proceedings of the American Association for the Advancement of Science, 1875, Detroit meeting.

concerning this bed of vegetation. Some of these localities are within the limits of Mower county:

Northwest quarter section 6, Beaver. Land of Andrew Oleson (Early.) It was found here at the depth of thirty feet, situated on a ridge in prairie country. It was two or three feet thick, and had a blue clay both above and below it—then struck a lime rock.

N. E. ¼ sec. 12, Le Roy, Mower county. Land of D. B. Bosworth. This was also on a high ridge, with blue clay above and below it, and lay at the depth of about 25 feet below the surface. It had a depth of seven feet, and contained "decayed stuff, like pressed hay."

N. E. ¼ sec. 1, Le Roy, Mower county. Land of Ole Knutson (Stoley): found at the depth of thirty feet; five feet thick; blue clay above and two feet of black clay below; then lime rock.

Sec 30, Bennington, Mower county, on land of Gents Everson. This is situated on a flat, and was found from 30 to 32 feet below the surface. It was three feet thick, and lay below blue clay. Below it was gravel to the thickness of eight feet, when the well struck lime rock.

S. E. ¼ sec. 9, Bennington, Mower county; land of John Mehan. It here had blue clay both above and below it, and a thickness of two feet. It lay at the depth of twenty feet. The underlying blue clay was gravelly.

It was met in the same town on Robert Cooper's land, at the depth of twenty-five or thirty feet. It was here on a very high ridge. It was in a blue clay, with gravel both above and below. It was here three or four feet thick. This well was abandoned on account of quicksand.

On the slope, northeast from Mr. Cooper's, it was reported to have been met with at the depth of six or seven feet from the surface, on the land of Mr. Bass.

Sec. 2, Sumner. Land of Wm. Bailey: met a deposit which was embraced between layers of what was then supposed to be lime rock. This deposit was two feet thick, and consisted entirely of wood. Rock was struck at the depth of eight feet. This wood was thirty-five feet below the surface. The owner called the rock "grindstone rock." (This was probably the Austin sandstone, of the Cretaceous, and the wood a lignite belonging to same age.)

N. part of sec 28, Spring Valley; land of A. B. Hutchinson. An irony deposit, having an unknown thickness, was struck at the depth of thirty-five feet.

This was also met in the central part of Racine, on the farm of D. Reed, at the depth of twenty-five or twenty-six feet, having a thickness of two or three feet. It came up in chunks which glistened, and looked like iron ore.

Under the head of *Cretaceous* the reader will find further statements concerning this iron ore. Two miles west of Spring Valley, on the land of O. H. Rose, Mr. Leonard made an observation on a deposit of surface crag. This he found abundantly cemented with iron, lying on a sloping surface, covering twenty-five or thirty

square rods, rendering the land unfit for cultivation, in the vicinity of no rock bluff, and on a prairie country. Iron ore was thrown out of a well S. W. ¼ sec. 24, Bloomfield. It was said to have come out in chunks, and to be as heavy as iron. It rises to the surface and a plow cannot be passed through it. This is owned by Geo. H. Smith. Again on H. T. Odell's land, section 36, Bloomfield, it is found in scattered lumps variously mingled with the soil, and with other stone. These surface pieces are impure, and often hold cemented gravel and pebbles. They are also loose and porous, and pass into ocher. Similar pieces occur on section 1, Beaver, land of O. A. Boynton.

Wood was taken from two wells in Jordan township, sections 29 and 30, on land of M. Robbins and Geo. Hare. This is also on a high prairie. In Mr. Hare's well was said to have been a tree.

Wells.

In order to study further the thickness of the drift, and its lateral extent in the county, a great many observations were made on the phenomena of common wells, and the tabulated list herewith appended will give the results of some of those examinations. It has already been said that there are a great many subterranean streams, especially within the area of the Trenton limestone. Some of these streams gush out along the river bluffs, and give rise to copious springs. Wherever there is an open rock structure, which is not imperviously covered by the drift or by the loam, it acts to receive the surface water and to allow its passage along lower levels to the main river valleys. This necessitates the drilling of a great many wells which penetrate in the rock to a depth, sometimes, of two or three hundred feet before reaching water.

Wells in Fillmore County.

Owner's Name and Location.	Drift or Loam, Feet	In the Rock, Ft.	Total, Ft.	Kind of Water	Remarks.
Public Well, Fountain	12	290	302	....	Water at 130 feet, but lost it by entering a cavity after [drilling five or six feet deeper.
W. H. Strong, Carimona	20	43	63	Good.	Drilled.
Poor Farm, section 4, Canton	22	30	52	Good.	In yellow sandrock; last two feet in clay.
Wm. Holton, Carimona	22	38	60	Good.	Drilled.
J. H. Hall, N. E. ¼ section 9, Bloomfield	41½	....	41½	Good.	Sand and clay.
E. Steffins, Spring Valley	6	80	86	Good.	"On the ridge."
Col. C. G. Edwards, Spring Valley	6	47	53	Good.	"On the ridge."
Calvin E. Huntley, Spring Valley	7	31	38	Good.	Very Hard water.
Peter Swab, section 6, Jordan	8 in.	69	70	Good.	In a "red sandstone."
Wm Twiggs, 1½ miles S. E. of Spring Valley	10	40	50	Good.	Three wells; same depth.
S. S. Belding, Etna	10	22	32	Good.	Hard water.
J M. Rexford, N. E. ¼ section 36, Bloomfield	20	75	95	....	
James Smith, S. E. ¼ section 18, Beaver	5	50	55	Good.	Water in limerock.
A. C. Seelye, Lenora	20	55	72	Good.	
M. L. Potter, Lenora	90	....	90	Good.	No rock.
Old town Well, Lenora	About 20	....	55	....	"In a large crevice in the rock."
Wm. Barton, 1½ miles N. of Lenora	20	110	130	....	
James Walsh, section 20, Amherst	13	67	80	....	Sandrock and limestone; water in limestone.
Wm. Kimber, S. W. ¼ section 29, Amherst	34	82	116	....	
S. S. Stark, N. W. ¼ section 2, Amherst	28	100	128	....	Gets dry in summer.
Henry Rose, N. E. ¼ section 3, Amherst	25	117	142	....	Gets dry in summer.
Public Well, Highland P. O	....	....	65	....	
Andrew Vogt, S. W. ¼ section 20, Amherst	7	85	92	No water.	Well incomplete.
Mrs. Simmons, section 35, Spring Valley	8	35	43	Good.	Last three feet in bluish-green shale.
Public well, Spring Valley	12	2	14	Good.	
A. N. Hart, Spring Valley	14	6	20	....	Last foot in bluish limestone; Some "oily blue clay."
S. W. Knight, section 11, Fillmore	15	95	110	Tolerably good.	
S Hoff, Fillmore	18	8	26	Good.	Eight feet in St. Peter sandstone.
D. S. Hoff, Fillmore	18	....	18	Good.	Sand and gravel.
John Kleckler, S. E ¼ section 26, Spring Valley	4	27	31	Good.	Twenty-seven feet in Trenton limestone.
F. Greaves, Chatfield	10	40	50	Good.	Forty feet in blue limestone.
Th. Simpson, Chatfield*	9	31	40	Good.	Thirty-one feet in blue limestone.
W. H. Dunham, Chatfield township	10	50	60	Good.	Ten feet yellow clay and stone.
Elisha Leonard, section 14, Sumner	17	....	17	Good.	Six feet of water.
J. B. Silbert, 2 miles E. of Spring Valley	19	....	19	Good.	Two layers of gravel.
C. B Brocksom, 2¼ miles E. of Spring Valley	16	33	49	Good.	Nine feet in drift; seven feet in loose rock.
F. Lageirg, 3 miles E. of Spring Valley	About 20	32	52	Good.	
J. H. Hall, 2 miles S. of Spring Valley	27	14½	41½	Good.	Clay, quicksand and bluish-stone.
O. H. Rose, 2¼ miles W. of Spring Valley	20	29	49	Good.	"Found a vein of Venetian Red 10 feet from the surface."
O. H. Rose, 2 miles W. of Spring Valley	8	48	56	Good.	Soil, gravel and clay.

* There are but few wells in Chatfield, because of the necessity of drilling from twenty to a hundred and fifty feet in the limestone.

The price charged by Mr. Huntley, of Spring Valley, for drilling wells, is one dollar per foot the first fifty feet, with twenty-five cents per foot added every ten feet thereafter. Messrs. Sands & Tousley, Amherst, receive fifty cents per foot before striking the rock, one dollar and twenty-five cents per foot for the first twenty feet in the rock, and add twenty-five cents per foot every ten feet.

The Loess Loam.

The greater portion of the county is covered with this loam. It contains no gravel or boulders, or with very rare exceptions, but consists almost entirely of fine siliceous material which becomes in some places quite clayey, making a very slippery mud when wet. This in outward appearance is of a light, yellow or rusty color, and differs in that respect from the loam seen on the drift-covered portion of the county, which is frequently black, or brown, varying to an ash color when mingled with a considerable per cent. of clay from the drift, and also contains gravel. The loess-loam is very homogeneous over wide tracts, while that in the drift area is subject to local and sunden variations. The loess-loam is indistinctly stratified, especially in the valleys, but the usual appearance is that of non-stratification. This stratified arrangement is rendered the less evident from the great similarity of the materials from the top to the bottom. It does not consist, apparently, in any change from coarse to fine in the sedimentation, but in a *lamination* of the homogeneous clayey, loam, and is easily obliterated by exposure, or by trickling water. This condition was noted particularly at Preston, and indicates that it was deposited in still, or gently moving, water. Where this loam lies over the old northern drift, it pass through a gravelly stage, the materials of the loam mingling with the coarser portions of the drift, and becoming finally replaced by the drift. The drift patches covered by this loam, pertaining to the eastern and central portions of the county, and believed to belong to an earlier drift epoch, are, so far as seen, made up of gravel and sand, with small stones. *No drift clay*, like that which covers the western part of the county, has been seen overlain by the loess-loam, except that which pertains to the general drift sheet of the northwest, and which occupies a narrow belt of 5 or 6 miles wide, where the loam overlaps the later drift. It would be reasonable, however, to expect that some such clay would be found. The pebbles that are thus mixed with the lower portion of the loam are smooth and waterworn, not covered with a coating of decayed

material of the same nature as the pebbles themselves, as they would be expected to be if the loam were derived from the decay, *in situ*, of the materials of the drift. The thickness of the loess-loam sometimes reaches twenty feet in the open upland, and, under favorable circumstances, where it might have accumulated laterally, as well as perpendicularly, it is much more. It is tickest in the eastern part of the county.

Alluvial Terraces.

At Preston, besides the flood plain, the river has a high terrace-plain. The Stanwix House stands on it. It consists of loam undistinguishable from the loess-loam that covers that portion of the county. The same may be seen at Lanesboro, and at Whalen, but it is not conspicuous. At Rushford fragmentary remains of this high terrace are seen in the valleys of the tributary streams. Along the main valley they are not well preserved. There are two terrace levels, besides the flood-plain. The highest terrace plain is from 70 to 80 feet above the second, and about 130 feet above the river. The lower terrace, on which Rushford stands, is about 40 feet above the river, and is probably never reached by the river in even the highest water. Within this lower terrace-plain, which spreads out laterlly and forms the most of the alluvial land between the rock-bluffs, is the river channel, and a still lower flood-plain about 20 feet above the river at low stage. A similar high terrace is seen along the Mississippi river at Winona, in Winona county, rising about 95 feet above the river, while the flat on which the city of Winona stands is about 25 feet above the river at the boat landing, in low stage of water. At Rushford and Winona the high terrace consists of a material different from the loam that overspreads the country, being made up of stratified sand. This terraced condition of the valleys of Root river, and of the Mississippi, is confined, so far as observed, to the loam-covered area, which nearly coincides with the "driftless area," as defined and described by Prof. Whitney.

Material Resources—Fuel.

In addition to the products of the soil which will always be her chief source of material wealth, Fillmore county cannot expect any important mineral discoveries to augment her material prosperity. She has a good supply of forest for purposes of common

fuel, and will not suffer from the absence of coal, as some of the counties further west have suffered. She will have to depend on her native forest trees, or on those that are being propagated successfully, for the most of her home fuel supply. There is as marked an absence of peat in this county as there is in Mower, but a single locality being noted. That occurs on S. E. ¼ sec. 26, Spring Valley, land of John Kleckler and David Broxlem, and is said to be about four feet thick, covering four or five acres. There is no doubt but other, isolated, small areas, of a turf-peat, also exist in the county, but the circumstances which promoted the production of so large a surface of peat in Freeborn county, are certainly wanting in Fillmore county. The frequency of lakes and swamps, and abundance of peat, coinciding as they do in Freeborn county, taken with the absence of both in Mower and Fillmore, point to the existence of a common cause for these surface features.

Iron.

Throughout the western portion of the county there is a great deal of surface iron, manifesting itself generally in the form of a cement in gravel, forming a dark-colored *crag*. There is also much evidence of the existence of a heavy continuous layer or deposit of limonite iron ore a few feet below the surface, in Bloomfield and Beaver townships. The details of these localities, and of the evidence of iron, so far as ascertainable, have been given under the heads of *Cretaceous* and *Drift*. Should this bed prove to be extensive, its actual value for commercial purposes may vary greatly from its intrinsic value. It consists of a loose-textured hydrated peroxyd, with ochery impurities, and bears a close resemblance to some bog-ore deposits; but its occurrence on high land, instead of in swamps, necessitates some other explanation for its existence than that ascribed to the occurrence of most bog-ore deposits. It may have originated during that swampy condition of Southern Minnesota when the peat grew that is embraced in the drift deposits, as already detailed. It is not probable that it will ever be found valuable for the manufacture of iron. Before the opening up of the vast, and richer, iron ore beds of Michigan and Missouri, the bog-ores were considerably used in the production of iron, on a small scale, in several of the western States, but the small furnaces that smelted them have all ceased operations many years ago. Another obstacle to the utilization of this deposit in Fillmore county, will be the lack of fuel in convenient and sufficient quantities.

Lead.

While the Galena limestone, which is eminently lead-bearing at Dubuque and Galena, passes, in its northwestern trend, across the southwestern portion of Fillmore county, it has not been discovered to afford the same amount of lead as in Iowa and Illinois. Indeed, at points more remote from the Mississippi river, in Iowa, no remarkable deposits of lead have been obtained from it. There is not a total absence of lead from its layers, since a few localities are known to have afforded it in limited quantities. The same is true of the lower Trenton; which seems to indicate that the presence of lead in the limestones of this region does not depend on the kind or age of the formation, but rather on some later, superimposed conditions that prevailed over the region, subjecting various formations to the same influences.

Quicklime.

All the limestones of the county are suitable for quicklime, but by far the greater quantity is made from the upper Trenton. In the townships of Sumner and Spring Valley, all the circumstances necessary for the cheap and rapid production of quicklime of the best quality co-exist, viz.: a suitable limestone, abundant exposure, and plenty of fuel. The Trenton there forms some of its characteristic outcrops, constituting the bluffs of the streams continuously for many miles, and rising a hundred or a hundred and fifty feet above the valleys. The kilns are built at the foot of the bluff, and the stone is cheaply obtained, without much cost of transportation. Wood is also abundant at present, much of that portion of the county being covered by a heavy forest growth.

The following list of lime-burners, with their localities and estimated production for the year, will give some idea of the extent of the business now carried on:

Palmer and Miller, Bear Creek, three kilns	2,000 bushels.
N. E. Fetterly, Bear Creek, three kilns	5,000 bushels.
L. G. Odell, Bear Creek, three kilns, (one draw-kiln)	5,000 bushels.
Charles Gorton, Bear Creek, one kiln	1,000 bushels.
Allen Brothers, Bear Creek, one kiln	1,000 bushels.
J. Finley, Bear Creek, one kiln	2,000 bushels.
Isaac Kegley, Bear Creek, one kiln	600 bushels.
Lem. Stout, Bear Creek, one kiln	2,000 bushels.
T. J. Hammer, Bear Creek, one kiln	2,000 bushels.
Elder Cyrus Young, Bear Creek, two kilns	Not in use.

Harvey McQuillan, Bear Creek, two kilns....................	Not in use.
Olds and Braley, sec. 9, Spring Valley, one kiln.............	2,000 bushels.
I. N. Cummings, sec. 11, Spring Valley, one kiln............	
J. H. Hall, sec. 12, Spring Valley..........................	3,500 bushels.

These all burn the upper Trenton, and there is no noteworthy difference in the quality either of the rock or of the lime produced. According to the testimony of several, however, there are certain layers, near the bottom of the formation, which are not suitable for quicklime. Some layers also are arenaceous, and have to be avoided, but the great mass of the rock is exceedingly well adapted to making quicklime.

The kilns used are, for the most part, of the rudest construction, presenting no improvement over the ancient and well-known "pot-kiln." They have to be emptied and refilled for every burning. Mr. L. G. Odell has the only draw-kiln seen in the county. In this part of the county, mixed wood sells for two dollars or two dollars and fifty cents per cord. The average price of lime is twenty-five cents per bushel, but it fluctuates from twenty to forty. In July, 1875, it was selling for twenty cents; but in September it brought forty cents. The lime itself is generally nearly white after being burnt, but in some places it has an ashen white color, though on slacking it is always white. It slacks with rapidity, evolving considerable heat. It requires from sixty to seventy-two hours to burn a kiln, depending on the size of the kiln, and somewhat on its shape, and consuming about ten cords of dry mixed wood. When freshly and thoroughly burnt, one bushel by measure weighs about 75 pounds, but if not well burnt, it will exceed 80 pounds. "Delivered at Spring Valley, by weight it is sold at the same price as by measure at the kiln." When shipped from Spring Valley it generally goes west, to points along the Southern Minnesota railroad, and is known as *Spring Valley white lime.*

Throughout the county, where the Trenton limestone appears, there are other lime-kilns that supply the local demand. The following were noted:

At Carimona, by William Renslow.
At Forestville, by Frank Turner.
At Chatfield, by Dennis Jacobs.
Sec. 35, Carimona, by Mr. Rollins.
Sec. 25, Canton, by Simon Houck.

The Shakopee is not used for making lime in Fillmore county, though it is extensively burned in the lower Minnesota valley, at

Mankato and at Shakopee. The St. Lawrence limestone is somewhat employed for this purpose, and affords a lime that is nearly white, and is said to weigh 80 pounds per bushel of measure. At Lanesboro this lime sells at $1.25 per barrel, or fifty cents per bushel, wood costing five or six dollars per cord. Mr. Sherman's kiln holds about 300 bushels, and requires 10 to 11 cords of wood for thorough calcination, burning about 48 hours. But little is shipped from here. The lime is about white, and slacks perfectly white. The following list embraces all known kilns that are run from the St. Lawrence:

At Lanesboro; by B. Sherman.
At Lanesboro, by Moses Greer.
At Lanesboro, by Mr. Butler.
At Rushford, by Jos. Otis.
At Rushford, by Wm. Crampton.

Brick.

There is no lack of materials for making common red brick. In some places the surface of the drift clay is used, containing some fine gravel, and at others the loess-loam. Brickmaking machinery was met with in the survey of the county at the following points:

Sec. 20, Spring Valley, J. W. Smith.
Forestville, Michael Shields.
Preston, Franklin Coleman.
Lanesboro, Thomas Dunsmore.
Chatfield, Wm. Stafford.
Lanesboro, W. H. Roberts.
Rushford, Ole Tuff.
Granger, (formerly,) Mr. Ferris.
Peterson, ———.

Gold, Copper.

In small quantities gold has been washed, by rude methods, from the drift at several points in the county. It was found on Luke Hague's land, in gravel, northeast quarter section 26, Spring Valley, and at Yeariton's saw mill, section 31, Jordan. There are accounts also of fragments of native copper having been found in the drift. It is hardly necessary to say that these discoveries do not indicate any valuable deposit of the kind in the rocks of the localities where they may be found. They pertain to the drift, and have

been transported hundreds of miles along with the other foreign substances in which they occur, from the northern part of the State. Such discoveries have sometimes awakened an interest that has culminated in stock companies formed for mining, and in the wasting of thousands of dollars. Similar small quantities of gold can be got by a minute washing of the drift at almost any place where the drift sheet is attenuated, or where the older glacial drift has been denuded, leaving the gold, which is indestructible, either by the lapse of time or by the chemistry of the elements, on the rock surface underlying. Almost every geological report in the country makes mention of them, extending at least through Ohio, Illinois, Indiana, Wisconsin and Iowa.

Building-Stone.

With this necessary article Fillmore county is also well supplied, and it has been put to an extensive use. There are hundreds of openings made to supply a local demand, besides a great many more extensive quarries which are known for a good many miles round. A great deal of stone for building is shipped to counties west, which are drift-covered, and without accessible building stone. Probably three-fourths of the building-stone used in the county is derived from the Trenton, the other fourth being made up of the Galena and the St. Lawrence. The Lower Trenton is most frequently employed. This is largely owing to the prominent manner of its outcrops, as shown under the head of *Drainage* and of *Surface-Features*. The Upper Trenton has been used in the construction of several schoolhouses and private residences. At Spring Valley the Galena is principally used. At Lanesboro, Whalen, Peterson and Rushford, the St. Lawrence. The Shakopee and Jordan are but rarely resorted to.

Probably the best known quarry in the county is that of Mr. Joseph Taylor, near Fountain. It is situated near the railroad, from which a side track allows the loading of cars. It is in the Lower Trenton, and supplies the "blue limestone" that is so largely shipped by the Southern Minnesota Railroad to points on its line in Mower, Freeborn and Faribault counties. The beds are usually less than six inches in thickness, and they are easily broken to any desired size. It is a hard stone, not easily cut, but can be dressed if necessary. It is not injured by disseminated shale, as much of the Lower Trenton is, and hence makes a very durable material. Mr. Taylor delivers it on the cars at $4.50 per cord of 128 feet. At Fountain are several buildings constructed of this stone.

Besides the quarries in the Trenton that have been mentioned in giving the scientific geology of that formation, a number were visited at which no new facts of interest were noted. Such were Ole Oleson's, northeast quarter section 36, Harmony; Wm. Wilbright's and Martin Quinn's, section 15, Forestville: George Drury's, section 8, Bristol; Garrett Mensing's, southwest quarter section 27, Forestville. It would be impossible, and unnecessary, to mention all the places where this limestone has been wrought. In traveling over the county a number of stone houses for residence were seen, belonging to farmers. Such are O. O'Hara's, southwest quarter section 18, Amherst, from the Trenton; Mr. George Park's, section 37, Bloomfield, from the Galena of Mr. S. S. Belding's quarry. The stone mill at Preston is of the Trenton. Of the quarries in the Galena at Spring Valley, those of Mr. Shumaker and of Mr. Allen are the most important. The former furnishes a beautiful fine-grained cut-stone for trimmings, as well as stone for common walls. The latter supplies a darker-colored, and coarser stone, which has been considerably used.

From the St. Lawrence limestone a very fine building stone is obtained. It is a fortunate circumstance that very much of this formation is in regular, and often in heavy layers. These are also not so firm as to resist the usual means for quarrying. When the beds are broken the blocks are found to possess often a finely vesicular texture. Their color is a very light yellow, or buff, resembling that of the well known "Milwaukee brick." The principal buildings at Lanesboro, including the Lanesboro Hotel, the flouring mill of Thompson & Williams, the Presbyterian and Catholic churches, the public schoolhouse, and a number of stores, are of the St. Lawrence, quarried at Lanesboro, and from land owned by the Lanesboro Company. At Whalen are excellent opportunities for obtaining this stone in its best condition. It has been somewhat wrought on Whalen's Bluff. Quarries in the same are owned at Rushford by Wm. Crampton, Jos. Otis and Hiram Walker. Mr. Crampton's quarry furnished the stone put into Boyam's store, and also that of A. K. Hanson's. Mr. E. Larson's was built from Mr. Otis' quarry, and that of Kierland & Son from Mr. Walker's. At Amherst P. O. the Jordan is quarried some for foundations, and the Shakopee at Chatfield.

Sand for Mortar and Concrete.

Wherever the St. Peter sandstone is accessible it is employed for making mortar. It is equally good, for hard-finish, being, when ta-

ken from some depth, purely white and of very uniform fineness. There are, however, some portions of the county where it is much more difficult to obtain a sand suitable for common mortar. In the western part of the county a white sand, or one nearly white is obtained from deposits referable to the Lower Cretaceous. These have been mentioned under the head of *Cretaceous*. They are found on the land of C. C. Temple, southeast quarter section 8, Bloomfield, on section 17, Spring Valley, on Andrew McNee's land, northwest quarter section 22, Bloomfield, and on J. M. Rexford's, northeast quarter section 36. Mr. Temple deliver's sand at Spring Valley for $1.75 per load, of two tons. One team can haul five such loads per day, but generally hauls but three. From three to five hundred dollars worth are taken from Mr. Temple's sand pit annually. Besides these sources for mortar-sand, the Jordan sandstone, which is often as incoherent as the St. Peter, can be used to advantage, though it is rather more apt to be cemented by iron. There can be no question but the compact and impervious nature of the green shales of the lower Trenton have preserved the incoherency of the St. Peter, by preventing the downward percolation of ferriferous and calcareous waters, which certainly would have left their impurities in the form of cement among its beautiful white grains.

The proximity and cheapness of lime and sand have suggested the building of houses by mixing these substances in the form of a concrete. Several such are found at Fillmore, also in Jordan, and at Rushford; but this method is not general. The material is cast in the form of large brick, having the color of common brown mortar, and these blocks are laid up much like common brick walls. Patent presses are used to make the concrete blocks.

REPORT ON OLMSTED COUNTY.

BY M. W. HARRINGTON.

This large and wealthy county lies in the second tier of counties north of Iowa. It is separated from the Mississippi River by Winona county on the east. Fillmore and Mower counties on the south separate it from Iowa. It is bounded on the west by Dodge county and on the north by Goodhue and Wabasha counties. Olmsted county is nearly a rectangle with five ranges of townships east and west and four ranges north and south. The geometrical figure is rendered irregular by Wabasha county which takes out two townships from the northeast corner. This irregularity is farther increased by an east and west row of twelve townships on the western part of the south side of the county, and extending half a section farther west than the rest of the county. The county contains 18 complete townships of 36 sections each, and twelve sections in addition, making 654 sections or square miles in all.

The following table gives the area in acres of each of the townships of the county. It is from the office of the State Auditor, Hon. O. P. Whitcomb:

Name.	Township N.	Range. W.	Acres and Fractions.
Elmir	105	11	23,006.69
Dover	106	11	23,019.01
Quincy	107	11	23,038.81
Orion	105	12	22,992.53
Eyota	106	12	22,983.90
Viola	107	12	22,977.97
Pleasant Grove	105	13	23,020.13
Marion	106	13	22,963.10
Haverhill	107	13	23,005.91
Farmington	108	13	22,810.11
High Forest	104 105	14 (6 sections) 14	26,804.42
Rochester	106	14	22,973.76
Cascade	107	14	22,915.45
Oronoco	108	14	22,968.06
Rock Dell	104 105	15 (6 sections) 15	26,809.22
Salem	106	15	23,002.35
Kalmar	107	15	22,990.60
New Haven	108	15	23,057.89
Total acres and fractions	....	....	421.341.96

Drainage.—Streams are plentiful and their fall moderate. The water reaches the Mississippi by three paths. The central, northern and western parts of the county are drained by the Zumbro River. This stream runs north into Wabasha county, when it turns east and makes its way to the Mississippi. It comes into Rochester from the southwest, and within the city limits Bear Creek, from the southeast, Silver Creek, from the east, and Cascade Creek, from the west, empty into it. Near the north line of the county it receives quite a stream resulting from the union of the Middle and North forks of the Zumbro. The southern tier of townships are drained by Root River, which, very sinuous, takes a generally east course for the Mississippi. It has in the county no affluents of any size, except at Chatfield, where a stream of small size comes in from the north On the eastern border of the county some branches of the small Whitewater River reach this county.

There are no lakes in the county. There are a few small ponds which in no sense deserve the name of lakes. Streams which sink into the ground and disappear are said to be not rare. The U. S. surveyor's plat of Farmington township lays down one such stream. Another is laid down on other maps in Elmira township; and another in Haverhill and Viola townships. From reports in various parts of the county, it seems they prevail where either the Lower

or Upper (Galena) Magnesian limestone occurs—a state of things to be expected, as will be noted when these formations are discussed.

Living springs of cool, pure water, of the best quality, are not rare. They are by far most common on the south or west sides of bluffs, where the green clay of the lower part of the Trenton Limestone comes to the surface. This clay is impervious to water. The formations dip slightly toward the southwest. The layer of clay forms a nearly level floor of which the southern and western sides are lower than the others. The water will consequently come out on these sides. The springs are frequently of large size. The phenomenon of a row of springs some distance up the sides of a bluff, while the base of the bluff furnishes no springs, is by no means a rare one. Spongy earth is apt to collect about the mouth of the spring. When filled with water, it is soft and very miry. In former times, when the road crossed such spots, bad mudholes were found. They have now been generally tapped and drained, though they are still occasionally met on the less-traveled roads.

Water-powers.—Olmsted county is more than usually favored with good water-powers. This results from the large number of streams, the swiftness of their currents and the favorable nature of the banks and bottom. The information which is given in the following table was derived from Mr. F. T. Olds, of the firm of Olds & Fishback, owners of Rochester City Mills, and from John M. Cole, owner of Zumbro Mills.

Water-Power Mills in Olmsted County.

Name of Mills.	Owner.	Location.	Stream.	Feet of Head.	Run of Stone.	Capacity per day.
Rochester City Mills	Olds & Fishback.	Rochester City	Zumbro......	16	4	100 bbls.
Zumbro Mills....	Jno. M. Cole.....	"	Zumbro with Bear Creek	10	4	100 bbls.
Cascade Mills....	Lyman Tondro..	"	Cascade Cr...	17	2	50 bbls.
Woolen Mill.....	Wm. Bartley.....	"	Bear Creek..	17	......	50 horse power, only partly improved.
Oronoco Mills...	Allis, Gooding & Hibberd	Oronoco Vil..	Zumbro......	15	7	150 bbls.
Middleton's Mill.	R. Middleton	Kalmar.......	"	6½	2	35 bbls.
Saw Mill.	Jas. Button......	New Haven...	"	6	......	
Stewartville.....	Chas. Stewart...	High Forest..	Root.........	12	......	50 bbls.
....	J. Fugle.........	Orion.........	"	8	......	50 bbls.
Custom Mill	— English	"	"	small.	small.	
Quincy Mills	....	Quincy........	Whitewater .	10	2 or 3	
Saw Mill.........	— Ambler.. ..	New Haven...	Zumbro......	10	......	

Several unimproved powers are reported. There are some between Rochester and the north boundary of the county, but bad bottom and banks prevent their improvement. There are said to be two good powers between Oronoco Mills and the main stream. An unimproved power is said to be found at Genoa. At High Forest village a water-power was improved years ago, but has been permitted to go to ruin.

The *Surface* is much diversified and the natural scenery very pleasing to the eye. The surface is generally rolling. Along the streams bluffs are found sometimes nearly 200 feet high. These bluffs are usually steep, level-topped, and characteristic of the geological formation which makes them. They are most common in the central and eastern parts of the county. Rochester lies in a valley, with bluffs all around it. It climbs the bluff toward the west. Dover Center, Marion and Chatfield lie in similar valleys. Curious isolated mounds are common, especially along the east side of the Zumbro in the southwest corner of Farmington and the adjacent corners of neighboring townships. They are also common in Elmira. Toward the west the surface is much more level. Much of Rock Dell township is like the prairies just south and west of it. The name of the township is derived from two or three rocky dells in its northern part.

The following notes were taken from the plats of the government survey of the county. These plats were not dated, but according to the State Auditor's records the county was surveyed in 1854 and 1855. They were found in the office of the county register, where access was given to them with the utmost courtesy:

Farmington.—(T. 108 N., 13 W.) This was a prairie township. From an isolated bluff in section 19 extended a stream which sank in about the middle of section 28. The magnetic variation varied from 8° 24′ to 9° 51′. Several marshes of some size were recorded.

Oronoco.—(T. 108 N., 14 W.) No marshes worth noting are shown on this plat. Wood accompanies the streams, varying from one to three miles in extent. The Zumbro on this and other early maps is called the Embarass R. The bluffs along the river are sometimes marked 100 feet. The magnetic variation varied from 8° 24′ to 9° 55′.

New Haven.—(T. 108 N., 15 W.) This township is represented as quite uneven, and bluffs occur along the streams. Woods follow the streams, and two or three aspen thickets are marked. The magnetic variation was 8° 55′ to 9° 54′.

Quincy.—(T. 107 N., 11 W.) This was mostly prairie when sur-

veyed. There was some wood along streams, and a few scattering thickets. A single small marsh was marked. Bluffs accompany the streams. Magnetic variation, 8° 27′ to 9° 51′.

Viola.—(T. 107 N., 12 W.) Several small marshes were marked. A range of prairie extended, east and west, through the middle. Prairie also occupied the northeast corner. Bluffs accompany the streams here also. Magnetic variation, 8° 26′ to 9° 34′.

Haverhill.—(T. 107 N., 13 W.) About half of the town is prairie. Woods extend, as usual, along the streams, which are accompanied by bluffs. Several marshes, none of great size, are platted. Magnetic variation, 8° to 9° 41′.

Cascade.—(T. 107 N., 14 W.) There are no marshes laid down in this township. It is nearly all prairie-land, brush accompanying the streams generally, and a few scattering thickets being marked. The bluffs along the river are sometimes quite elevated for the county. Magnetic variation, 8° 13′ to 9° 33′.

Kalmar.—(T. 107 N., 15 W.) Rather heavy timber occupies the northwestern part. An isolated grove is marked in sections 13 and 14. A single marsh is laid down in sections 11 and 12. The banks of the fork of the Zumbro are bluffy. Magnetic variation 8° 36′ to 9° 35′.

Dover.—(T. 106 N., 11 W.) The township is an essentially prairie one, though many isolated thickets are marked, and there is some wood along a branch of the Whitewater river. The marshes are few and insignificant. The magnetic variation is from 8° 40′ to 9° 50′.

Eyota.—(T. 106 N., 12 W.) A broad belt of timber, about three miles wide, crosses the township diagonally from the northwest corner. The magnetic variation, 9° to 10° 40′.

Marion.—(T. 106 N., 13 W.) Several marshes are given. The land is wooded along the streams, leaving about one-third of the township in prairie. Magnetic variation, 8° 40′ to 10°.

Rochester.—(T. 106 N., 14 W.) The township is mostly brushy, with scattering timber. Bluffs accompany the streams. Several marshes are laid down. Magnetic variation, 8° 15′ to 9° 50′.

Salem.—(T. 106 N., 15 W.) Two marshes of about 120 acres each, and one of about 160 acres are given. About two-thirds are marked as wooded, but the prairie portion comes at the north, where the streams are most abundant. The streams are not marked as bluffy. Magnetic variation, 8° 47′ to 9° 38′.

Elmira.—(T. 105, N. 11 W.) This township was about half-wooded. An independent drainage is marked in sections 8, 9,

16, 17. Bluffy mounds not on streams are marked. Magnetic variation, 8° 45′ to 10° 55′.

Orion (T. 105 N., 12 W.) is somewhat wooded along streams. In sections 10 and 15 a stream is represented as sinking. The banks of Root river are bluffy. A small lake is given in sections 35 and 36. Magnetic variation 9° 20′ to 12° 12′.

Pleasant Grove.—(T. 105 N., 13 W.) A large marsh of about 120 acres is laid down in the southern part of the township. A band of woods about 3 miles wide accompanies the river, the banks of which are bluffy. Magnetic variation 8° 25′ to 10° 57′.

High Forest.—(T. 105 N., 14 W., with a range of sections in T. 104 N., 14 W.) A large marsh—about 320 acres—is laid down in sections 30 and 31. The township is wooded along the streams, but is about half prairie. Magnetic variation 6° 45′ to 9° 55′.

Rock Dell.—(T. 105 N., 15 W., with a range of sections in T. 104 N., 15 W.) A large marsh—320 acres—in the northwestern part. The land along the streams is little wooded. The banks of the streams in the northern part are bluffy; in the southern, not. Magnetic variation 7° 40′ to 9° 18′.

There seems to be no easily recognizable order in the magnetic variation for different parts of the county. The extremes were 6° 45′ and 12° 12′, in High Forest and Orion respectively. Both these towns are on the south side and not far apart.

Some *elevations* have been taken on lines of railroad, built or proposed, through the county. Those of the Winona and St. Peter R. R. I have not been able to see. Mr. W. D. Hurlbut tells me that the survey for this railroad makes Eyota 1,210 feet above the sea, and gives the same height (1,210 feet) to Byron.

The following are elevations on the line of a proposed railroad from Wabasha to Austin, and along the lines of several other proposed roads. Some of them fall in neighboring counties, but they are given here to make them of general use. They are from the notes of Horace Horton, civil engineer, Rochester, who ran the lines on which the elevations occur. These elevations were referred to the level of low water in the Mississippi River at Wabasha. This is 30 feet below St. Paul and 620 feet above the surface of the ocean.

ELEVATIONS FROM THE NOTES OF HORACE HORTON, C. E.

	Above the Mississippi River at low water at Wabasha.	Above the Ocean.
1 Head of East Indian creek, 5 miles N. E. of Plainview, (Wabasha county.)	534	1,154
2 Street of Plainview (Wabasha county.)	518	1,138
3 Elgin, (Wabasha county.)	390	1,010
4 Near center of sec. 14, Haverhill	634	1,254
5 S. W. corner sec. 24, Haverhill, (Rock, seen some feet above.)	570	1,190
6 Base of Sugar Loaf, sec. 31 and 32, Haverhill	390	1,010
7 College street bridge, Rochester	340	960
8 Surface of water beneath	325	945
9 Summit of Lone Mound, section 11, Farmington, within 10 feet of Plainview level, viz.:	518	1,138
10 S. E. corner sec. 10, High Forest	667	1,287
11 Low water at High Forest village	570	1,190
12 Sec. 29, T. 104 N., 15 W., Mower Co., half mile south John Rowley's house	757	1,377
13 Dr. Thornhill's farm, 4 miles east Brownsdale, in Mower county	730	1,350
14 S. Minn. R. R. at Brownsdale, (Mower county.)	632	1,252
15 St. Paul and Milwaukee R. R. track at Austin, (Mower county.)	560	1,180
16 Chatfield, about	267	887
17 Pleasant Grove, about	667	1,287
18 Creek near the schoolhouse in sec. 15, Cascade, about	365	985
19 N. W. corner section 10, Cascade	500	1,120
20 Quarter stake, sections 33 and 34, Oronoco	490	1,110
21 Center stake, sec. 21, Oronoco	465	1,085
22 Surface of river at Oronoco	315	935

Lone Mound (elevation 9) is about 150 feet above the surrounding country.

Elevation 10 gives the summit of the water-shed between the Zumbro and Root Rivers. From section 5, Orion, to section 21, Rock Dell, the elevation of this water-shed does not vary 10 feet from the figures given. By comparing the figures in the table it will be seen that this water shed includes the highest land in the county of which we have any record of observations. A general elevation toward the south and southwest is visible. This elevation reaches its maximum in the counties south, which include in their borders the most elevated land in the State. On comparing the geological map of the county, accompanying this report, and the table of elevations, a striking relation between the altitude and ge-

ological formation is rendered manifest. This will be more particularly referred to under the heads of the individual formations.

Timber.—Heavy timber is found along the large streams, though it is pretty well cut out now. Aspen and brush thickets are common everywhere. The following trees, shrubs, and twining plants were observed while driving through the county:

I. *Trees.*

Basswood (*Tilia Americana. L.*)

Sugar Maple (*Acer Saccharinum. Wang.*)

Red Maple (*A, rubrum. L.*)

Soft Maple (*A, dasycarpum. Ehr.*)

The first two maples do not usually attain any considerable size, while the soft maple, in a state of nature, becomes a large tree.

Box Elder (*Negundo aceroides. Mœnch.*)

This tree is common along streams and is a favorite in cultivation. In transplanting it is trimmed up too much to easily take root. It is a pretty tree, of pleasing form and full foliage.

White Ash (*Fraxinus Americana. L.*)

Slippery Elm (*Ulmus fulva. Michx.*)

Corky Elm (*U. racemosa. Thomas.*)

Of which I saw several trees along the streets in Rochester. It was undoubtedly transplanted from woods close by.

White Elm (*U. Americana. L. pl. Clayt. Willd.*)

Black Walnut (*Juglans nigra. L.*)

A grove of these trees was seen in Kalmar.

Butternut (*Juglans cinerea. L.*)

Hickory (*Carya.*)

Only very small trees were seen. It is said that they are always cut when young to make round barrel-hoops, such hoops having been taken to be characteristic of barrels containing Minnesota flour. It is a destructive and pernicious practice, for thus one of the most valuable of trees is prevented from maturing. The only way to prevent it is to make square hoops the fashion for Minnesota, which could easily be done by a combination of the leading millers.

Bur-oak, (*Quercus macrocarpa. Michx.*)

Is very abundant. On prairies it is low, 3–8 ft. high, forming extensive thickets and fruiting abundantly. In more favorable localities it is larger and may become quite a tree.

White-oak (*Q. alba. L.*)

Is hard to distinguish at a distance from the preceding. Undoubted specimens were seen near High Forest.

Jack-oak, Yellow-oak, etc., etc., (*Q. coccinea, Wang. Var. tinctoria.*)

Like all the species of this group of oaks, this tree is hard to identify. It is very common but is gradually disappearing before civilization. It is frequently seen dead or dying, without apparent cause.

Paper-birch (*Betula papyracea. Ait.*)

Small, along streams in the northern part of the county.

American Aspen (*Populus tremuloides. Michx.*)

Very common, usually small.

Coarsely toothed Aspen (*P. grandidentata. Michx.*)

Cottonwood (*P. monilifera. Ait.*)

A great favorite in cultivation.

Balm of Gilead (*P. balsamifera. L.*)

Silver Poplar (*P. alba. L.*)

Lombardy Poplar (*P. dilatata. Ait.*)

The last three are introduced and are very common in cultivation.

Willows. Several species were seen, some of them becoming large trees.

White Pine (*Pinus strobus. L.*)

A few straggling specimens were seen on the bluffs three miles east Rochester.

Locust (*Robinia Pseud-acacia. L.*)

Is commonly cultivated. The same is true of several pines and spruces and a larch.

II. *Shrubs.*

Prickly Ash (*Zanthoxylum Americanum. Mill.*)

Smooth Sumac (*Rhus glabra. L.*)

Poison Ivy (*R. Toxicodendron. L.*)

False Indigo (*Amorpha fruticosa. L.*)

Lead Plant (*A. Canescens. Nutt.*)

Wild Plum (*Prunus Americana. Marshall.*)

Apparently several varieties, some of them producing the greatest abundance of pleasant fruit.

Wild Red Cherry (*P. Pennsylvanica. L.*)

Choke Cherry (*P. Virginiana. L.*)

Wild Black Cherry (*P. serotina. Ehr.*)

Nine Bark (*Spiraea opulifolia. L.*)

Common Meadow-Sweet (*Salicifolia. L.*)

Wild Rose (*Rosa blanda. Ait.*)

Wild Red Raspberry (*Rubus strigosus. Michx.*)

Wild Black Raspberry (*R. occidentalis. L.*)

Flavor of the fruit is said to be remarkably good.

Common Blackberry (*R. villosus. Ait.*) Not common.

Black Torn (*Cratægus tomentosa. L. Var. pyrifolia.*)

Black Thorn (*Cratægus tomentosa. L. Var. punctata.*)

Choke-berry (*Pyrus arbutifolia. L.*)

Am. Mountain Ash (*P. Americana. DC.*) Cultivated.

Eu. Mountain-Ash (*P. Aucuparia. Gært.*) Cultivated.

Red-osier Dogwood (*Cornus stolonifera. Michx.*)

Panicled Dogwood (*C. paniculata. L'Her.*)

Wolf-berry (*Symphoricarpus occidentalis. R. Br.*)

Sheep-berry, Wild Haw (*Viburnum Lentago. L.*)

Cranberry-tree (*V. Opulus. L.*)

Is frequently cultivated.

Hazel (*Corylus Americana. Watt.*)

Abundant on prairies.

Low Birch (*Betula pumila. L.*) Cold bogs.

Speckled Alder (*Alnus incana. Willd.*) Along streams.

Juniper (*Juniperus Sabina. L.*)

Seen only on a rocky bank on Root River—sec. 35. Rock Dell.

III. *Vines.*

Virgin's Bower (*Clametis Virginiana. L.*)

Frost Grape (*Vitis cordifolia. Michx.*)

Virginia-Creeper (*Ampelopsis quinquefolia. Michx.*)

Common wild and a favorite in cultivation. It is often erroneously called *Ivy.*

Shrubby Bitter-sweet (*Celastrus scandens. L.*)

Hop. (*Humulus Lupulus. L.*)

Wild and in cultivation.

THE GEOLOGICAL STRUCTURE.

The outcrops of rock are numerous throughout the county. It lies just at the edge of the system of deeply eroded valleys extending westward from the Mississippi. To the east of it are the deep ravines which cut through the high bluffs at the base of which the great river lies. The beds of these ravines gradually rise in receding from the Mississippi, and it is in Olmsted county that they rise to near the surface of the surrounding country. To the west and southwest of the county lies the great accumulation of drift which grows deeper and deeper as one passes westward. This material thins out over Olmsted. In the southwest corner it is thick enough to conceal entirely the rock-features below. Eastward it appears only in thin outliers, marking the ragged edge of deposition, or in patches and masses which are remnants left by subsequent erosion. In order to see to the best advantage the changes in the drift, features of erosion, and stratification, one must cross the county obliquely. There is the least drift, generally speaking, in the northeast corner, and the most in the southwest corner. On the other hand, the southeast and northwest corners are much alike in the very feature in which the other two corners differ. In a rough way the lines of change cross the county diagonally in a southeasterly and northwesterly direction. This is due to two facts which may have some relation with each other. In the first place the Great River in the vicinity of the county runs in a generally southeast direction. The erosion-valleys extending from it would tend to take a direction perpendicular to it, and the lines of equal depth of erosion would tend to be parallel to it. Again, the dip of the rocks in this county is slightly southwest. The edges of the strata as presented on the surface would tend to be in lines perpendicular to this direction.

There are no signs of noteworthy upheaval, depression or other changes in the relations of the strata to each other in this county, as in the whole of this part of the state the strata are conformable. The peculiar structure of the bluffs enables one to trace some of the strata at a distance. As far as the eye can follow them their planes occupy the same position with reference to the horizon. The only exception to this is the Cretaceous. Its rather doubtful patches in the county lie in nearly a horizontal plane, and across the edges of the strata below.

The strata of the rocks other than Cretaceous do not lie in a horizontal plane. The dip is very slight, and in this county is toward the southwest. Toward the northwest corner the line of dip alters a little, and is more southerly. Comparison of altitudes and strata over a larger portion of the State has convinced Mr. W. D. Hurlbut that the dip here is 10 feet to the mile southwest. All my observations in the county tended to prove the correctness of this estimate.

The stratigraphy of this fine county is easy to read in most cases. The form of the bluffs, the line of springs making a definite part of the Trenton, the differing solubility of the rock and the consequent occurrence of sink holes, caves, etc., in one formation and not in another, the lithological character of the rocks notably distinct in some of the formations, and the gradual and regular dip of the strata, which, when taken with the erosion, enables one to predict with much certainty the rock over which he is standing, even when it is hidden from view—all these enable one to read the stratigraphical enigma of the county with little trouble. In this study the intimate knowledge of the county possessed by Mr. Hurlbut assisted me greatly. He cheerfully rendered me all the assistance in his power, besides hospitably entertaining me at his house. The stormy weather of the season devoted to this work prevented me from visiting all of the county. In such cases the details of the map accompanying this report were put in by Mr. Hurlbut. You yourself, sir, as director of the survey, have frequently passed through this county, and your observations in it have not only confirmed many of my own, but have added facts which escaped my attention.

I will here embrace the opportunity of recommending Olmsted county as an excellent field for teaching stratigraphy. The strata are interesting, the characters mentioned above make the reading of them easy, the scenery is unusually attractive. I can conceive of no better spot to which to take a class of students for instruction in geological field-work.

The formations found in the county are not numerous. The Potsdam sandstone is said to be found in the beds of the Zumbro and Whitewater rivers, about where they leave the county. It has not been seen by me, however, and the sandstone is probably only one of the lower sandstone layers of the Lower Magnesian. The latter formation, the St. Peter sandstone, the Trenton limestone and the Galena, are found here, the first and last probably only represented by a part of their entire thickness. A little Cretaceous was found.

THE LOWER MAGNESIAN LIMESTONE.

The AREA of this formation in the county is as follows. It follows the larger streams, beginning on them when well in the county, and broadening out until it leaves the county with them. It appears in the beds of the branches of the Zumbro well up in Rochester, Marion, Haverhill and Cascade townships. Rochester lies on a floor formed by the upper surface of this formation. The valley of Rochester city is entirely shut in by bluffs, except where the Zumbro passes out to the north and along a geological valley, now dry, to the northwest. This lower magnesian valley of Rochester city is somewhat crab-shaped, and is formed by the meeting of the various streams which make up this branch of the Zumbro. Cascade township is about half Lower Magnesian, the remaining surface being occupied by spurs and islands of the formations above, one of these islands being quite large. Oronoco township is almost exclusively Lower Magnesian. Farmington is of the Lower Magnesian floor, except the southern edge and some outliers of Trenton and St. Peter. In New Haven the middle fork of the Zumbro soon rises to the Trenton, while the north fork lies on the Magnesian, until it passes into the next county west. A large portion of Quincy is Lower Magnesian, as is a little of the northeast of Viola. An arm of this formation appears at the surface in the bed of the river, passing nearly through Dover from east to west. Elmira is also floored with Lower Magnesian for the most part, as is a small portion of Orion. The village of Dover lies in a Lower Magnesian valley, something like that of Rochester city. The same is true of Chatfield. Something more than 20 per cent. of the county has a floor of Lower Magnesian.

The *Lithological characters* of the formation here partake of its general characters in Minnesota as described by the Director of the Survey in his First Annual Report (for 1872, pp. 81–83.) It varies from a compact, fine magnesian limestone to a pure, friable, saccha-

rine white sandstone. It is frequently in irregular layers, which are not continuous for any distance. Sometimes these layers are thin and continuous; sometimes they are thick and cleave naturally into massive blocks. The rock is often brecciated, occasionally massive. Broken cherty layers, irregular silicious pockets, mottled sandstone, oolitic limestone, vesicular limestone, sparry cavities of considerable size, are all found in this variable yet usually easily recognized rock.

This rock holds its form well and thus produces characteristic *surface features.* When worn deeply into by erosion it presents bold cliffs and craggy, rounded hills. When not covered thickly by drift, it makes a poor surface for agricultnre, as may be seen in some parts of Oronoco. It is nearly barren, and is covered with scant grass, with hazel and scrub oak (in this case dwarf *Quercus macrocarpa*) or with small paper birch, and other wood-growth not large enough to be of importance economically. When this floor is covered by drift, as in the beautiful prairie township of Farmington, the soil may be unsurpassed. The most of this township is devoted to wheat, and at the proper season it seems to be one continuous wheatfield.

A *section* of this formation is seen at Quincy Mills. It is described in the First Annual Report, (for 1872) p. 82, and need not be repeated.*

* *Note.*—As the report for 1872 is entirely out of print, the section at Quincy is hereby appended, in order to complete the geology of the county. No. 1 of this section is of the Shakopee limestone, and No. 2 is the upper portion of the Jordan sandstone.—N. H. W.

Descending Section at Quincy, Olmsted County.

No. 1.	Dolomitic limestone; quite arenaceous, falling out in huge masses which are rough, distorted in their crude bedding, and unmanageable as a quarry stone, showing much calc-spar. Limestone and sandstone are mingled with occasional strips of light-green shale. In general the face presents the appearance of an alternation of horizontal layers of thin and more shaly beds, with heavy, coarse and rough limestone beds. Some green shale layers alternate with dark, umber-colored (ochreous) shale, neither being more than two inches thick. They are tortuous and not continuous. This phase appears like the tops of the bluffs at Winona, but is probably at a considerably higher horizon......	30 ft.
No. 2.	Persistent, white sandstone, or granular quartzite, seen....	10 ft.
	Total exposure	40 ft.

The following section was taken at the lime-kiln of James Barnett, on section 8, Oronoco, just northeast of the village:

Calciferous sandstone, much broken, in thin layers, buff	14 ft.
Compact little broken calciferous sandstone, light buff	3 ft.
Sandstone (mostly saccharine) in layers	4 ft. 8 in.
Aluminous limestone, in thin layers, light buff	1 ft. 7 in.
Dark sandstone with numerous blue spots	1 ft. 8 in.
Arenaceous vesicular dolomite	3 ft. 6 in.
Like second above	4 ft.
Like second above, but more irregularly bedded	1 ft.
Vesicular, sparry, irregularly bedded dolomite	4 ft.
Total as far as seen	37 ft. 8 in.

The above section begins at the top. No fossils could be found. The lowest layer (last described) is employed by Mr. Barnett for making lime. The lime is light buff, slow, and contains considerable cement.

This lime is of considerable *economical value*. The lime of Barnett is good notwithstanding its slowness, and the cement in it only increases its value for many purposes. Mr. Barnett uses 12 cords of wood to one charge of his kiln. The wood costs $2.00 per cord. The kiln burns three days and affords 120 barrels of lime. Mr. Barnett says that the lime is slow in slacking, but that it sets quickly.

This rock does not furnish much good building material in this county. It is not of even bedding and homogeneous, texture generally. Pieces are sometimes employed at Rochester for window-caps and water-tables. These pieces are found only in the uppermost layers. No general use is made of them.

THE ST. PETER SANDSTONE.

The *area* of this rock is difficult to represent on a map. It is so friable that it will not endure erosion when left to itself. It is only when it is capped by the lower layers of the Trenton that it successfully resists the attacks of water. By itself, uncovered by other formations, it occupies but little space. It juts out beneath the cap of limestone only a few feet or rods. From a projecting spur of limestone it may extend farther, as is illustrated in the city of Rochester. A spur of Trenton comes in from the west and ends near the city limits. The sandstone, however, can be struck in sinking wells almost anywhere in the western portion of the city. Occasionally where erosion was incomplete an outlier of crumbling

sandstone can be seen, not capped by limestone. Such an outlier may be found in or near SW. Farmington. This must happen but rarely, and the outliers can attain but small size. Streams of considerable size usually leap from the Trenton to the Lower Magnesian, the intervening St. Peter sandstone having been washed completely away at an early period. Sometimes, however, streams of small size remain in a bed of St. Peter sandstone, in which case the valley is sandy, covered with small oaks, and worth little for agriculture. This is seen in the valleys of Bear Creek and its branches.

The *surface features* caused by the presence of this sandstone are interesting, and have already been referred to. As the incoherency of this formation deprives it of the power of resisting erosive forces, it is usually carried away cleanly wherever exposed. The consequence is a precipitous descent from the Trenton to the Lower Magnesian. This appears in lines of remarkable, level bluffs. The height of these bluffs is usually the thickness of the formation, with fifteen or more feet of limestone on the top. These bluffs are especially noticeable around Rochester. To the east their top is reached by a rugged ascent, to the west by gradual dip of the strata. The erosive forces have left many small and isolated bluffs, which can be properly described under this head, though the lower layers of Trenton limestone assist in their formation. They appear as rugged mounds rising from the Magnesian floor, and form a striking feature in the aspect of the neighborhood. They are most abundant in southwest Farmington and in Elmira. A few are seen along the railroad, just east of Rochester. Perhaps the most remarkable is "sugar-loaf mound," about two miles east of the city and close to the railroad. Its shape and relative proportions are those of a sugar-loaf. Another remarkable one is "Lone Mound," of section 11, Farmington. It is about three miles from the line of bluffs south. Two or three miles northwest are two similar mounds, called "Twin Mounds." They are in Wabasha county.

The thickness of the St. Peter was ascertained with an aneroid barometer, near Rochester. The upper layers of the Lower Magnesian were found on Bear Creek, near the woolen mills. The upper surface of the St. Peter was ascertained as carefully as might be near Whitcomb's quarry, and near Jenkins' quarry. Three comparisons were made. The proper allowance having been made for dip and atmospheric change, the value of 111 feet was obtained for the thickness of this formation.

The *lithological character* of the St. Peter is uniform and simple.

It is a rather coarse, white, friable sandstone, pure white, except where contaminated by foreign substances or percolations from the formation above. It contains no fossils so far as I could see in this county.

This formation is *useful* in several ways. When with a tight, magnesian floor, it holds water, and furnishes a good supply to wells. It is sometimes excavated where it comes out on the face of a bluff. Excellent cellars, dry and of uniform temperature, are thus formed which are used especially for the preservation of vegetables. It supplies an inexhaustible amount of pure white sand, round-angular, and excellent for mortar or glass-making.

THE TRENTON LIMESTONE.

As this formation lies next above the St. Peter, and as the dip is southwest, we should expect to find it just behind the sandstone. Such is the case, but being a coherent limestone it occupies much more *area* than the St. Peter. It covers fully one-half of the county, stretching in a broad, interrupted band from southeast to northwest. Its outer edge is the labyrinthine, interrupted line of level, peculiar bluffs which reach in their serpentine course every township in the county, except only Rock Dell and High Forest. The southwestern or upper edge of its outcrop can not be traced so minutely, as this formation passes insensibly into the Galena which overlies it. The formation covers the most of Kalmar, Haverhill, Viola and Eyota townships. It caps also with a few feet of limestone the most of the outliers of St. Peter already mentioned.

The *lithological characters* are described in the First Annual Report (already referred to) and need not be repeated.

In general, as seen in this county, we have, below, a shaly limestone, often presenting beds of blue limestone useful for building. This is more or less interrupted by shale and averages 15 feet thick. Above this is a bed of green shale more or less interrupted with limestone, and about 15 feet thick also. Above this we have 125 feet of yellow, or gray, harsh, magnesian limestone, in regular beds of varying thickness. In deep quarrying this rock also is blue.

Many sections of this rock can be seen. It is the rock most generally quarried. Several sections for Olmsted county are given on pp. 97–99 of the First Annual Report of the survey (for 1872.) The characters of others examined by me were uniform with those there described.

Many fossils are found in these beds. *Chaetetes Lycoperdon* is

plentiful in the green shale. *Leptaena*, *Orthis*, *Strophomena*, *Murchisonia*, *Pleurotomaria*, *Orthoceras* are common. The orthoceratites are unusually large.

This stone is the one most used in this county for building purposes. The stone for the buildings about Rochester were for the most part taken from the Trenton quarries near by. The quarry of W. Jenkins, just within the city limits, furnishes a large proportion of this stone.

It has been suggested that the clay of the green shale would make good brick or pottery. The grain is very fine, but the presence of small, calcareous fossils injures it for these purposes. A pottery factory, in which this clay was employed, started some years ago, had to be abandoned on this account.

THE GALENA LIMESTONE.

The *area* of this formation in the county is much less than that of the Trenton. It is found only in the southwestern part of the county, and covers rather less than 20 per cent. of the whole area. Byron, in Kalmar, is located on this rock. It underlies nearly all of Salem and High Forest, and considerable parts of Rock Dell, Rochester and Pleasant Grove. It extends into Marion and Orion, and Mr. Hurlbut tells me that a small scalp of it may yet be found in the western part of Eyota township. The lower and upper edges of its outcrop can not be accurately traced. In the case of the lower edge it is for the reason already mentioned, viz.: the Trenton and Galena blend gradually. The upper edge cannot be traced because it is completely concealed by drift.

In *lithological character*, as seen here, this rock is a heavily bedded, buff dolomite, fine grained, or coarse and porous. It contains often small pieces of iron pyrites, which, by weathering, give it ferruginous stains. Lead has not been found in place in the rock, but farmers sometimes find it isolated on the surface, evidently left behind when the rest of the rock material was weathered away. It often contains crystals of spar; sometimes irregular cavities are found. Under the influence of the weather the rock is seen to vary in solubility. The result is frequently sink-holes of varying dimensions Such holes, a few feet deep, are common on the bluffs of this formation, and I was informed by Mr. Hurlbut of an extensive one on the bluff near Garrick's quarry, the bottom of which has never been reached. Another result of this unequal weathering is the craggy appearance of the bluffs formed by the Galena.

This limestone is well displayed in this county at Garrick's quarry,

Sec. 17, Rochester township. The floor of this quarry is about 80 feet above the Trenton. To the top of the quarry is about 35 feet. The rock is a sparry, magnesian and more or less arenaceous limestone. It is in beds one to three feet thick, separated by very thin layers of light blue shale. The beds are massive and yellowish, somewhat stained with iron, arising from the decay of iron pyrites. The upper portions are most arenaceous and fossiliferous. In the crevices is found abundance of satin spar, and in the largest ones stalactites may be found.

R. Williams' quarry, on the north bank of Root river, Sec. 31, High Forest township, is in this formation. This rock is exposed for 25 feet, and is dolomitic, more or less concretionary, with small, spar-lined cavities. It is sparingly fossiliferous. The upper six feet are much broken up. The remainder is compact and unevenly bedded. The concretionary structure is not visible on fresh surfaces. It is brought out by weathering and especially by burning, and then appears in the form of fine rusty lines.

On the left bank of the same stream, about one mile west of Williams' quarry, is an exposure of yellow thin-bedded, broken, uneven, dolomitic limestone, of which only 8 or ten feet are visible. I found no fossils, but was sure, from the lithological characters, that the rock is Galena.

The same rock is well exposed in the ravines of Salem and Rock Dell, where it is quarried to some extent for building.

As to *economical value*, this formation produces the best building stone found in the State. It is much used in Rochester, but has been mostly derived from Mantorville, in Dodge county. It will be further described under that head. At Russell Williams' quarry, near High Forest, it is burned for lime. There are five kilns at this place. Each kiln takes 12 cords of wood for one charge of stone. The wood has to be brought from a distance, and costs at the kiln $6.00 per cord. Three hundred barrels of lime are burned in a kiln. The lime is white and fine, and has the best reputation of any lime hereabouts. It sells at $1.00 per barrel.

THE CRETACEOUS.

A careful search along Root River and elsewhere in the southwest corner of the county, failed to afford me the slightest trace of the Maquoketa shales, which would be naturally expected overlying the Galena. An outcrop was found a few rods west of P. Brewer's residence, in the southwest quarter of section 35, of Rock Dell

township, on the north bank of Root River, the character of which is doubtful. The formations in the adjoining counties, and the lithological character, indicate the probability of its being Cretaceous, and it is thus marked on the accompanying map. The exposure is along a road-track going down to a ford of the stream, and was partially covered with soil and overgrown by bushes. The following is the section from below upwards:

Compact, blueish limestone	2	feet.
Indurated, arenaceous, yellowish shale	1	foot.
Yellow sandstone, in broken layers	1	foot.
Light blue clay	½	foot.
Reddish, broken sandstone	1½	feet.
Light blue clay	¼	foot.
Sandstone	1	foot.
Sandy, bluish clay	½	foot.
Total seen distinctly	7¾	feet.

The same arrangement of alternating sandstone and clay could be traced indistinctly four or five feet farther up.

Three rods farther down the river is a compact limestone, siliceous, not dolomitic, non-fossiliferous, much broken by frost. The line of meeting of this with the preceding was concealed by soil and overgrowing plants.

The first described is in all probability Cretaceous; the second I am unable to refer to any formation with certainty. Perhaps it is Cretaceous, perhaps Niagara.

A scalp of Cretaceous, containing fossils in abundance, is said to have been found in the western part of Eyota township. It was of very limited extent.

THE DRIFT.

This covers much of the county. It thins out toward the northeast. It is of considerable thickness in the southwest. Its edge is ragged and shows extensions, which, however, are not in conformation with the present drainage system. It consists of blue clay, washed or yellow clay, stratified gravel and sand, and boulders.

The blue clay is by no means continuous. It is found in limited areas, and bands in various parts of the county. Sometimes it forms distinct ridges, as in western Rochester city and in the valley directly east of Rochester. In such cases it usually abuts on a bluff.

The washed clay, as its name indicates, has been worked over by

water since its deposition in the drift. It occupies low pond-like spots, or abuts on the bluffs. It is usually of a uniform reddish-yellow color and quite arenaceous. Sometimes it is in colored layers of red, yellow and green. In this case its derivation is probably from the green shale of the Trenton as well as from the drift. The washed clay is used for bricks.

The exposures of sand and gravel are not extensive in the parts of the county examined by me. Where seen they exhibit the usual characters. The boulders are entirely absent in most parts of the county. In many scattered localities, again, they are abundant; and in the southwest corner of the county they are often found of great size.

The following table of wells will be useful for an analysis of the drift. The facts were furnished by O. Sprague, practical well-digger. Mr. Sprague is an observing man, and has probably dug more wells than any one else in the county:

Wells in Olmsted County.

O. SPRAGUE.

Location.	Owner.	Depth in feet: Drift.	Rock.	Total.	Water.	Remarks.
35. Farmington ...	C. E. Stacy.	22	31	53	Good.	5 feet black soil; then reached clay.
35. Farmington....	W. H. White.	20	24	44	Good.	Yellow clay and blue rock.
36. Farmington....	E. Raymond.	11	..	11	Good.	Blue clay.
25. Farmington....	W. Searles.	44	..	44	Good.	14 feet black heavy soil; remainder blue clay.
30. Haverhill	J. P. Simonds.	25	10	35	Soft.	25 feet sand; 10 feet hard sand rock.
9. Haverhill	P. H. McGovern.	40	50	90	Good.	Red, hard drift.
32. Haverhill	J. E. Brown.	25	..	25	Good.	4-5 feet soil, then sand.
11. Haverhill	B. F. Bulen.	12	..	12	Plenty.	Red, hard drift.
14. Salem...........	Z. Holt.	25	..	25	Good.	Sand all the way.
14. Salem...........	J. D. Fuller.	40	..	40	Good.	Sand all the way.
26. Salem..........	J. P. Fosdick.	30	6	36	Soft.	White, hard rock.
21. Salem...........	Ole Severson.	27	..	27	Good.	Sand.
16. Salem	C. Peterson.	25	..	25	Good.	Sand.
16. Salem	Nils Jacobson.	25	.	25	Good.	Sand, foot of bluff.
16. Salem...........	T. Thomson.....	57	16	73	Good	Red, hard drift; white limestone.
28. Salem...........	....	32	..	32	Good.	20 feet blue clay.
30. Pleasant Grove.	Fred. Sibeck.	61	..	61	Good.	48 feet blue clay.
29. Pleasant Grove.	J, Collins.	21	..	21	Good.	15 feet blue clay.
25. Pleasant Grove.	D. W. Hymes.	20	40	60	Good.	Sandy, red clay.
11. Cascade........	T. C. Cumings.	30	..	30	Plenty	25 feet blue clay.
17. Cascade.......	J. H. Hodgman.	25	..	25	Plenty.	Sand.
17. Cascade........	E. Babcock.	25	..	25	Plenty.	Sand.
15. Cascade ...	P. Boardman.	30	..	30	Plenty.	Red, sandy clay.
15. Cascade.......	J. Gardner	30	..	30	Plenty.	Red, sandy clay.
15. Rochester......	I. M. Westfall.	40	..	40	Plenty.	Sand.
2. Rochester......	W.L.Brackenridg	18	..	18	Plenty.	Sand.
5. Viola.....	D. D. Whipple.	44	50	94	Plenty.	

Cedar logs at considerable depths in the drift are found but rare-

ly. Mr. Sprague says they are always under the blue clay. Rotten wood is occasionally found in the blue clay.

It is a striking fact, often mentioned, that water is often found on the bluffs at a much less depth than at their base. The geological formation satisfactorily accounts for this.

Brick are made at many places in the county. Oronoco, Eyota, Pleasant Grove and Byron furnish brick. The most of them are made at Rochester. E. P. Brown burns 350,000 a year. Whitcomb Bros. burn, as they tell me, 1,200,000 brick per year, in five or six kilns. The brick here and at Brown's are machine made. V. Whitcomb has a small brickyard near that of Whitcomb Bros. In all cases coming under my observation the brick are made from the washed clay. This is in beds from two feet to ten or twelve feet or more. Although this material is sandy, more sand is usually put in in making the brick, which are consequently tender, and of poor quality. The brick vitrify but little when burned.

No peat was observed in the county. In some lowlands the turf is thick and comparatively free from inorganic matter. This will burn and produce some heat, but it is much inferior to proper peat. I saw no peat-bogs nor any extensive accumulations of peat-producing plants of any kind in the county.

Gold has been found in the drift along the Zumbro from Rochester and Oronoco down to the Wabasha border and beyond. It is found only on the Lower Magnesian. Murchison calls attention to this fact as generally true. It is found in the drift about the stream, but mostly in the bed of the stream or in material worked over by it at a comparatively recent date. In the same alluvial material is found a small amount of black sand, of a specific gravity approaching that of gold. When the gold is obtained by washing, after all the other materials are washed away this heavy black sand remains, and the minute fragments of gold are picked out from it. It is therefore here called the "mother of gold," and the two are thought to be always together, a conclusion which need not necessarily follow.

The gold is in minute, angular fragments. The quantity is so small that it does not pay to work it by the ordinary method of hand-washing. Washing on a more extensive scale might be made to pay. It has been tried two or three times, but never under favorable circumstances, or for periods of any length. It remains yet to be seen whether it will pay or not.

It may be worth while just here to call attention to the fact that gold is frequently found under these circumstances. It has been

found over extensive regions in Canada, where attempts at obtain-ing it on a large scale have always failed to pay. I have heard of it in Vermont, Ohio, Wisconsin and Iowa. The Director of the geological survey reports it from several places in Minnesota besides this, i. e., in Fillmore county, at Jordan, in Scott county, etc., etc. From all these facts the conclusion may be drawn that the prospects of its paying in Olmsted county are not good.

4 ft. black loam and reddish clay.
2½ ft. rubble stone.
3 ft. of dolomitic rock, yellow, with fine reddish lines; layers broken 2-8 in. thick.
3 ft. of bluish stone, less dolomitic, in even beds 1-2 ft. thick.
1 ft. of bluish stone, not dolomitic in thin layers.
3½ ft. of heavy layers of bluish stone, not dolomitic.

17 ft. total exposure.

Below this is a compact limestone, not well exposed. It is not dolomitic and is good for burning.

At the sawmill near the middle of sec. 17, of Milton, the road passes around an exposure of rock. Here are about 10 feet of shaly limestone and blue clay. A fine specimen of *Receptaculites* lay in the wheel-track of the road, and had been considerably marred. Many other incomplete specimens were found.

An eighth of a mile below this saw mill, (still in sec. 17 of Milton,) is an irregular bluff on the south side of the stream. It is concealed by debris, bushes, etc., and not very accessible. The following measurements and observations were obtained with as much accuracy as circumstances would admit. They are taken from above:

10 ft. of yellowish limestone in thin layers.
1 ft. of compact aluminous layers in 2 or 3 layers.
15 ft. of shale, limestone and blue clay in alternate layers, usually thin.

Below, passing under the debris and probably occupying the present river-bed is a thick stratum of compact limestone, with a depth of upwards of 20 feet. *Receptaculites* are abundant in the rock.

As might be anticipated from the structure of the rock, living springs are abundant along these bluffs. One very fine one, the size of one's arm, pours out from the rock just above the sawmill, at a distance of 20 feet above the water of the stream. Here these springs are almost equal in numbers in bluffs facing north or south, betraying the absence of dip at this point in either of those directions.

Other small exposures of Trenton rock were seen in the road in several places within the Trenton area as marked on the accompanying map, as at sections 19 and 30 of Milton township, and in sections 12, 13 and 14 of Mantorville. The lower parts of the exposures at Mantorville and Wasioja are, in all probability, Trenton, but as it is impracticable to tell where this rock begins, and

DODGE COUNTY.

BY M. W. HARRINGTON.

This county lies immediately west of Olmsted county. Its form is that of a rectangle. It is a small county, having four townships in a north and south direction, and three in an east and west. Its area is as follows. This table is taken from the office of the State Auditor, Hon. O. P. Whitcomb:

AREA OF DODGE COUNTY.

Name of Township.	Township.	Range	AREA IN TOWNSHIP. Acres.
Vernon	105	16	23,067.39
Canisteo	106	16	23,111.88
Mantorville	107	16	23,054.88
Milton	108	16	22,964.09
Hayfield.	105	17	24,123.32
Ashland	106	17	24,123.40
Wasioja	107	17	24,081.86
Concord	108	17	24,233.99
Westfield	105	18	23,030.33
Ripley	106	18	23,008.72
Claremont	107	18	22,898.42
Ellington	108	18	22,950.72

The total area is 280,688.90 acres, or nearly 438½ square miles. In addition to this, Rice Lake covers 61 acres in this county.

Drainage.—The water flows, for the most part, to the east and northeast by means of the branches of Zumbro River. The largest

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of these branches is the South Branch of the Middle Fork of the Zumbro, which rises in Rice Lake, on the western border of the county, and flows eastward through nearly the central portion. The north branch of the same stream has its source in the wet prairies in the northwest corner of the county and flows nearly eastward also. The south fork of the Zumbro reaches this county by two small branches which have their sources in the southeastern part. Cedar River enters near the southwestern angle of the county. It drains Westfield and a part of Hayfield. The fall of the streams is inconsiderable in all parts of the county, but is greater in the northern part of the county than in the southern.

Rice Lake lies partly in this county, partly in the county next west.

Water Powers.—Two streams only furnish them in this county. These are two branches of the Zumbro, both branches of middle fork. The following is the list of these powers:

Mills.	Owner.	Location.	Stream.	Head Feet.	Stone. Run.	Kind of Mill.
Wasioja	A. Mason & Son..	Wasioja Village	Middle Fork.	9	4	Cus. & flour.
Blake's	J. D. Blake.... ..	Sec. 13, Wasioja	Middle Fork.	12	4	Flouring.
Mantorville..	Adams & Kneeland	Mantorville Vill	Middle Fork.	{ 10 / 7 }	3	Custom.
Rockton.....	John Bradford.....	22, Mantorville.	Middle Fork.	8	2	Cus. & flour.
Agawam.....	Chase & Swaringan	13, Mantorville.	Middle Fork.	12	2	Flouring.
Eagle Valley.	J. Gordon..........	15, Concord ...	North Fork..	12	2	Custom.
Buchanan ...	Widow Irish.	Buchanan Vill..	North Fork..	10	...	Saw mill.
Milton.......	James Elias.......	9, Milton	North Fork..	8	2	Custom.

Of the above mills that at Mantorville has two powers, one about 110 rods below the other. Agawam Mills is the latest name for what has been called Dodge County Mills and Bunker's Mill. An unimproved mill-privilege was found at Concord. The Middle Fork of the Zumbro rises in Rice Lake. This lake also has a natural outlet toward Straight River on the west.

In order to give the mills just enumerated on the Middle Fork as much water as possible the western outlet to the lake has been cut off. Yet for three or four months in the winter of 1874–5 the mills had no water. Some years, however, they continue to have water the year through. The water in the North Branch is even more unreliable than this.

The *surface* is but little diversified. The southern and southwestern part of the county is prairie-land. In the northeastern portion bluffs of some hight are found along the streams. The southwestern part of the county is marshy and thinly settled. The region around Rice Lake is also low and marshy.

The plats of the government surveys were examined in the office of the county register and the following notes were made:

Vernon (105, 16) contains considerable grub-land and a small thicket. The remainder is all prairie. The magnetic variation is from 8° 20′ to 9° 06′.

Canisteo.—(106, 16.) A few acres of marsh and a small pond are found in this township. About two-ninths of the township is set down as brush land. The remainder is prairie. Magnetic variation, 8° 26′ to 9° 0′.

Mantorville.—(107, 16.) This township has a small marsh laid down about 40 acres in extent. A considerable portion of the township is pretty heavily wooded, especially along the streams. Magnetic variation, 7° 24′ to 9° 10′.

Milton.—(108, 16.) A small marsh of 25 acres is platted. The northern half is mostly wooded. The southeastern part is wooded, and isolated groves are found on the remainder. On the portions marked prairie are often found notes of "barren thickets," "barrens," "scattering timber," &c. Magnetic variation, 6° 45′ to 10° 0′.

Hayfield.—(105, 17.) It is but little wooded, only about 16 per cent. The remainder is prairie. Magnetic variation, 7° 40′ to 8° 55′.

Ashland.—(106, 17.) A pond of about 10 acres is found on the eastern line of section 25. About one-ninth of the township is wooded. Magnetic variation, 7° 55′ to 8° 50′.

Wasioja.—(107, 17.) A small marsh of about 160 acres is laid down in sections 8 and 9; also a patch of wet land of 240 acres in the western part of the township. Wood follows the main stream, and a few scattering patches are found elsewhere. The remainder is prairie. Magnetic variation, 7° 22′ to 8° 30′.

Concord.—(108, 17.) Eight small marshes varying from 8 to 40 acres are platted. Some woods but mostly open. Magnetic variation, 6° 25′ to 8° 47′.

Westfield.—(105, 18.) Three marshes from 50 to 320 acres each are recorded. A little wooded land is also present. The remainder is prairie. Magnetic variation, 7° 24′ to 8° 19′.

Ripley.—(106, 18.) A stream terminates in a marsh of 100 acres in section 4. The same is true of a long one near the northeast corner. In addition to these 15 marshes are laid down. They vary from 10 to 320 acres. Some wood is found but the township is mostly prairie. The magnetic variation varies from 7° 10′ to 8° 15′.

Claremont.—(107, 18.) Besides the marsh around Rice Lake,

G. F. Rhodes, of Kasson, makes brick from a reddish wa clay obtained from a bank in the village of Mantorville. He ma about 600,000 brick per year. A kiln contains 120,000 and ta 40 cords of wood at a cost of $4.00 per cord. The brick sell $7.00 per thousand. No sand is put in the clay, and the brick machine pressed. The brick are tender, like others made fr washed clay, except when the burn is exactly right.

The clay in the bed used by Mr. Rhodes varies in the amount alumina. From the richest clay he has made a batch of drain til They are tough and have the characteristic color of such tiles. makes three sizes which he sells as follows:

2 inch bore at	$15 00 per thousand.
3 inch bore at	17 50 per thousand.
4 inch bore at	20 00 per thousand.

In sec. 17 of Milton Township, Jacob Baumgartner has a kiln which he occasionally burns *lime*. I was unable to see either li or quarry, but the former is said to be whitish and the stone is e dently Trenton Limestone.

In sec. 10 of Milton Township, N. Irish has a kiln in which burns lime. The stone is a bed of Travertine, light, porous a soft, apparently 3 or 4 feet thick. The bed is at the base of a sm knoll and seems to have been deposited by a spring now runni over the bed, though Mr. Irish claims that this spring now produc soft water. I was unable to ascertain the extent of the bed. On hundred and forty barrels of lime are burnt in one kiln, which take 6 cords of wood, at $1.50 per cord. The lime sells at $1.00 per barrel at the kiln. Thirteen kilns a year are burned. The lime is very white and quick.

STEELE COUNTY.

BY M. W. HARRINGTON.

Position and size. This county lies in the second tier of counties from the Iowa line. It lies next west of Dodge county, being the fourth in number west from the Mississippi river. It has the form of a rectangle, and is bounded on the south by Freeborn, on the west by Waseca, and on the north by Rice counties.

The name, position and size of the townships are as follows. The figures were obtained from the office of the State Auditor, Hon. O. P. Whitcomb, with some additions from the office of the county register:

Position and Area of the Townships.

Name.	T.	R.	Acres & Hundredths.
Blooming Prairie	105	19	22,621.83
Aurora	106	19	22,964.98
Havanna	107	19	22,254.04
Merton	108	19	22,901.48
Summit	105	20	22,982.48
Somerset	106	20	23,001.47
Owatonna	107	20	22,912.82
Clinton Falls	108	20	11,446.00
Medford	108	20	11,483.57
Berlin	105	21	22,805.78
Lemond	106	21	23,005.80
Meriden	107	21	22,798.25
Deerfield	108	21	22,326.99

The total number of acres of land are seen to be 273,455.39. In addition to these there are about 428.66 acres of lake in Blooming Prairie; 676.33 in Havanna; 182.30 acres in Berlin; 144.46 in Meriden; 601.79 in Deerfield. The total lake area in the county

is thus made 2,038.54 acres. Adding this to the acres of land, we have 275,488.98 as the total acreage in the county.

Surface.

This county is quite level, and is covered heavily by drift. As will be seen the rock appears at the surface only along the Straight River, near its exit from the county. Grassy swales are common and characteristic of the swamps, especially in Lemond township. Gravelly knoles are quite common in the most of the county, especially in the southern part. They are short and steep in the south part of Somerset and the adjoining parts of Summit and Blooming Prairie. A long straight ridge with many boulders runs nearly on the township line between Aurora and Somerset. The southern part of the county is called the Wilderness and is not thickly settled. The level of the Milwaukee and St. Paul Railroad has been already published. The writer has been unable to get access to that of the Winona and St. Peter Railroad.

The following notes were taken from the field-notes and plats of the government survey in Steele county, access to which was obligingly given me by the County Register. The surveys were made in 1854.

Blooming Prairie, (105, 19,) was covered by thickets and low scrub for the most part. Marshes were numerous and there were two small lakes in the northern part of the township. Magnetic variation, 8° 10′ to 9° 45′.

Aurora.—(106, 19.) This township much resembled the last; thickets and scrub over the most it and numerous marshes, some of them quite large. Magnetic variation, 7° 45′ to 9° 45′.

Havanna.—(107, 19.) This township contains the major part of Rice Lake. It is for the most part brushy or wooded, but the southwestern part is prairie. Marshes are numerous but not large. Magnetic variation, 7° 44′ to 9° 25′.

Merton.—(108, 19.) This township was found to be wooded on the south side and in the northwest corner. The remainder was prairie. A large marsh was located in sections 23 and 24, and many smaller ones were scattered over the county. Magnetic variation, 7° 37′ to 9° 23′.

Summit, (105, 20) was wooded in the eastern half, prairie in the western. A large branching marsh is located along the streams, and there are a few isolated marshes. A stream from the south loses itself in the southwest corner of section 20. Magnetic variation 9° 18′ to 10° 23′.

Somerset (106, 20) had several sections of prairie in the northeast corner, and the portion of the township lying west of the Straight River was prairie; otherwise it was wooded. The marshes platted are few and not large. Magnetic variation, 9° 13′ to 10° 45′.

Owatonna, (107, 20.) A band of woods, 2-5 miles wide, crosses the township accompanying the Straight River, and lying on its eastern bank The remainder is prairie. The banks of the stream were bluffy. Magnetic variation, 9° 10′ to 10° 45′. The site of the city of Owatonna was already in part claimed when the survey was made (1854.)

Clinton Falls (south half of 108, 20) was mostly wooded, though a wedge of prairie lay between the Straight River and Crane Creek. There was also a little prairie on the eastern border. There was a long marsh platted in sections 26 and 27. Magnetic variation, 9° 10′—10° 30′.

Medford.—(north half of 108, 20.) This township is prairie, except for a wooded strip 2-4 miles wide, east of the river. The banks of the stream are rather bluffy. The claims of Sanburn, in section 16, Collings and Johnson, in 9, and Wright, in section 5, were already made. Magnetic variation, 8° 35′ to 10° 30′.

Berlin, (105, 21,) was wooded through the center of the township; the remainder was for the most part prairie. The plats indicate marshes along the streams, and some other scattered marshy spots. Near the center lie Looigana and Beaver lakes, and in the southwestern part a pond. Beaver Lake is now said to be deep and clear, and to contain only soft water. This item, and much other valuable information concerning this county, the writer owes to Rev. G. C. Tanner, superintendent of schools for the county. Magnetic variation, 8° 45′ to 10° 34′.

Lemond.—(106, 21.) The northwest part was woody and marshy, and there are besides two or three isolated groves of small extent. An extensive marsh crosses the north end of the township. Magnetic variation, 10° 00′ to 11° 13′.

Meriden.—(107, 21.) This township was nearly all prairie, a little wood being found north of Crane Creek and also a small amount in the southern part. The land along the creek was marshy. On the northern boundary a small lake was found. Magnetic variation, 10° 22′ to 11° 30′.

Deerfield.—(108, 21.) A lake enters from the south. Another of about 220 acres is platted just northeast of this, and near it is a pond of about half the size. All the township was wooded except the northwest corner, which was prairie. Extensive marshes were

platted in the southern and western part. Magnetic variation, 9° 30′ to 11° 40′.

On comparing the magnetic variations given above, it is found that the extremes are 7° 37′ in Merton, and 11° 40′ in Deerfield, being a variation of more than 4° in one small county.

Drainage.

This county is well provided with lakes, as may be seen in the preceding notes. Marshes also are numerous. These are due to the level character of the country, and to the very slight elevation of one part above another. The small amount of the elevation is further shown by the sluggishness of the currents in the various streams. The course of the Straight river shows that what elevation there is in the county, its increase occurs as we travel southward. But, although the county is very nearly level and has little change in elevation within itself, its elevation with reference to the rest of the State is considerable. This is shown by the fact that two streams origninate here, viz.: the Straight river, in the southern part of the county, and a branch of the Zumbro in Rice Lake. It is worthy of remark here, though it was mentioned in the report on Dodge county, that Rice Lake has a natural outlet into the Straight river as well as into the Zumbro.

The small amount of fall of the streams limits the mill privileges in this county. The mills are found only on the Straight River, at Owatonna, and north.

The City Mills at Owatonna, Drought & Whitson, owners. They have 7 feet head of water, and three run of stone. It is a custom mill, but does a little flouring business.

Clinton Mills are at Clinton Falls, Sherman & Winship, owners. They have 10 feet head of water, and three run of stone. It is a custom and flouring mill.

Medford Mills are at Medford, White, Beynon & Co., owners. They have 10 feet of head of water and 4 run of stone. They do only a flouring business.

There is said to be an available water-power, unimproved, at Lindensmith's between Owatonna and Clinton Falls.

Timber.

The time spent in this county was not long enough to make out a list of the woody plants at all approaching completeness. The following were noted:

Basswood. (*Tilia Americana. L.*)
Smooth Sumach. (*Rhus glabra. L.*)
Wild Grape. (*Vitis.*)
Virginia Creeper. (*Ampelopsis quinquefolia. Michx.*)
New Jersey Tea. (*Ceanothus Americanus. L.*)
Sugar Maple. (*Acer saccharinum. Wang.*)
Silvery Maple. (*A. dasycarpum. Ehr.*)
Red or Swamp Maple. (*Acer rubrum. L.*)
Box-elder. (*Negrundo aceroides. Mœnch.*)
False Indigo. (*Amorpha fruticosa. L.*)
Locust. (*Robinia Pseudacacia. L.*) Cultivated.
Wild Yellow or Red Plum. (*Prunus Americana. Marshall.*)
Cherry. (*Prunus.*)
Red Raspberry. (*Rubus strigosus. Michx.*)
Blackberry. (*R. villosus. Ait.*)
Crab. (*Pyrus arbutifolia. L.*)
Dogwood. *Cornus paniculata. L'Her.*)
Wolfberry. (*Symphoricarpus occidentalis. R. Br.*)
Ash. (*Fraxinus.*)
Slippery Elm. (*Ulmus fulva. Michx.*)
White Elm. (*U. Americana. L. pl. Clayt.*)
Butternut. (*Juglans cinerea. L.*)
Walnut. (*Juglans nigra. L.*)
Hickory. (*Carya.*)
Bur Oak. (*Quercus macrocarpa. Michx.*)
Black Oak. (*Quercus coccinea, Wang. var tinctoria, Bartram.*)
Wild Hazel-nut. (*Corylus Americana. Walt.*)
Iron-wood. (*Ostrya Virginica. Willd.*)
America Aspen. (*Populus tremuloides. Michx.*)
Cottonwood. (*P. monilifera. Ait.*)
Largetoothed Aspen. (*P. grandidentata. Michx.*)
Balm of Gilead. (*P. balsamifera. L. Var. candicans. Ait.*) Cultivated.

Geology.

The heaviness of the drift over this county effectually covers all the rock. The slight fall of the river enables it to uncover but little thus covered up. The only exposure of rock in the county is at Lindensmith's, about two miles below, and this exposure is but a slight one.

The rock is *Trenton Limestone*, and is first met at John Abbott's quarry, in section 33, of Clinton Falls. It is in the bed and on the low banks of the Straight River. The exposure at the time visited extended only about 4 feet above the surface of the water. The rock is in horizontal layers, 2–6 inches thick. It is blue on fresh fracture, yellow when weathered, compact, sparry, and contains many minute fragments of blue shale, like the corresponding rock at Minneapolis.

Just below, on section 28, is Lindensmith's quarry. The rock is in thicker layers than in Abbot's quarry. The following section was seen in one place, beginning above:

2 feet loam.
2 feet blue clay and limestone in thin layers.
4 feet—to water's surface—compact blue limestone, in thin layers.

The rock is like that in Abbott's quarry. Near by was another section as follows:

2½ ft. black and red loam.
2 ft. hard yellow clay.
7 ft. blue stone in layers 2–5 inches thick, extending to surface of water.

Below this there is no more rock until the county line is passed. At Wolcott Mills, about 1½ miles in Rice county, blue Trenton limestone has been quarried in the bed of the river.

No fossils were found in the rock. This stone is used for flagging and other purposes at Owatonna, and is considered a good stone.

Some evidence of the existence of a *Cretaceous* area in the State was found. On the southeast quarter of section 26, of Deerfield, on the farm of Aug. Hoffmann, coal has been found in sinking a well. Dr. G. A. Rossbach tells the writer that they went through 25 feet of black-blue clay, in the under part of which were fragments of coal. After that they passed through gravel in which also were coal fragments. At the depth of 63 or 64 feet rock was struck, the drill showed it to be black slate with pieces of coal imbedded in it. Although no specimens of the coal were seen by the writer the description given would answer for Cretaceous lignite. When the matter is further explored by capitalists which will, in probability, soon happen, all doubt as to the geological horizon of the rock will be cleared up. Meantime the evidence from the geology of adjoining counties, as well as the nature of the rock itself, justifies us in calling the rock Cretaceous. Just west of Owatonna another farmer is said to have struck coal also, though the writer was unable to get any further information on the matter.

The *Drift* is here, as already mentioned, very heavy. Sections of it were seen at several places. A gravel-knoll cut through at Owatonna showed one foot of black loam on the top, then four feet of yellow, sandy clay, then seven feet of assorted sand and gravel. Other sections along the railroads showed essentially the same arrangement. Among the gravel-pebbles, fragments of argillite were common.

The Owatonna mineral springs should be mentioned. They are nine in number, and are located about one and one-half miles northeast of the city. They lie along Maple Creek, at the base of a low clayey bluff. Of the five seen by the writer, four deposited iron. The water of the fifth had a decidedly bluish tint. Fountain spring was put down 22 feet and now flows out freely, raising the water about five feet above the surface. The others are natural springs. They are all undoubtedly due to the clay-floor underlying the loose materials of the drift. The taste of the water in the five visited by me was slightly mineral. The analysis of the water, published by the Owatonna Mineral Springs Company is appended. To which of the springs this analysis belonged could not be ascertained:

In one gallon, or 231 cubic inches, there are:

Chloride of Sodium	.1680	grains.
Sulphate of Sodium	.2856	"
Bicarbonate of Sodium	1.8592	"
Bicarbonate of Calcium	13.1992	"
Bicarbonate of Magnesium	5.2920	"
Bicarbonate of Protoxide of Iron	.6160	"
Alumina	.2800	"
Silica	1.1200	"
Organic Matter		a trace.
Total	22.8200	grains.

Cornell Brothers, at Owatonna, manufacture stoneware. The clay employed is a fine, rich, plastic, blue clay, and is at present obtained from Eldora, Hardin county, Iowa. This bed of clay is being exhausted, and its quality is deteriorating. This has determined the firm to try a gray clay found about one mile east of Owatonna. This is the same layer of clay which crops out at the mineral springs near the city. It has been found to work well. Excellent fire-brick is made from this clay. This firm has just started in business. They make about 1,000 gallons a week in jars, jugs, &c.

Dr. E. N. Morehouse makes brick from a bluish, yellow, washed clay, near Owatonna. He puts in the clay about one-third sand. He makes 225,000 bricks a year, for which he charges $8.00 to $12.00 per thousand, according to quality. He uses 50 cords of wood for every 100,000 of bricks. The wood costs $3.00 per cord at the place of cutting. The bricks are, like all of those made from

the washed clay, not first-class. Dr. Morehouse has experimented on making unglazed red ware from his clay, with fair results.

Odell and Cornell also make bricks near Owatonna. Bricks are also made on the farm of Mr. Skinner, near Blooming Prairie.

An artesian well has been subscribed for at Owatonna, and will probably soon be sunk. It must obtain results of great value for the Geological Survey.

TOPOGRAPHY.

The lists of railroad elevations given in the first annual report carried a net work of levels over the most of the inhabited portion of the State. They demonstrate the nearly level condition of the general surface of the State. The changes of level are, in that portion through which railroad lines have been run, of the nature of broad swells in the substructure, and indicate the changes in the geological formations, that bring on a series of hard and very enduring rocks, or a thickness of more erosible layers. Thus the Upper Devonian, in the southern tier of counties, is characterized by a considerable elevation above the formations that underlie it. The level surface that characterzes the Cretaceous in Steele and Dodge counties, as well as in much of the western part of the State, is attributable to the effect of that formation in toning down, and concealing, the irregularities in the old Devonian and Silurian surfaces. Thus there subsists a very intimate relation between the topography and the geology in the various parts of the State. The illustrations that have already been given in the report on the geology of Fillmore county, are still more striking proofs that the topography of a country is that which gives the first response to the enquiring geologist when locating the geological boundaries. For this reason it is highly desirable that all lines of railroad survey, which have been run in the State, should be made tributary to this end. It matters but little whether the railroads for which such surveys were intended were ever constructed. All that is needed is the comparative hights of the points along a known line. The undulations of the surface are very significant to the geologist.

The following lists are given as a further contribution to this subject. They have been furnished by the engineers of the Chicago, Milwaukee and St. Paul Railroad, and refer the points named to the level of the ocean. They pass through some of the principal cities and the wealthiest counties of the State.

RAILROAD ELEVATIONS.

THE CHICAGO, MILWAUKEE AND ST. PAUL R. R.

From the Records, by Robert Angst.

IOWA AND MINNESOTA DIVISION.

[*Note.*—The track is designated in all cases, when not otherwise mentioned.]

	Above the Ocean.
	Feet.
State Line, Lyle	1,099.46
Rose Creek, (Grade)	1,085.41
Rose Creek, (Bottom)	1,063.03
Dobin's Creek, (Grade)	1,094.76
Dobin's Creek, (Bottom)	1,071.46
Y at Austin Junction	1,094 45
Austin, (Station)	1,097.06
Wolf Creek, (Grade)	1,103.06
Wolf Creek, (Bottom)	1,076.06
Cedar River, (Grade)	1,100.00
Cedar River, (Bottom)	1,080.06
Ramsay, (Crossing S. M. R. R.)	1,114.86
Indian Creek, (Grade)	1,110.06
Indian Creek, (Bottom)	1,096.56
Lansing	1,124.06
Ingham's Creek, (Grade)	1,120.86
Ingham's Creek, (Bottom)	1,107.56
Top of swell, NE. ¼ Sec. 33, Udolpho, (Cut 3½ feet)	1,143.56
Swell, half a mile south of Madison, (Cut 1½ feet)	1,149.56
Madison	1,150.06
Top of divide 7½ miles N. of Madison, (Natural Surface)	1,149.50
Top of divide 7½ miles N. of Madison, (Grade)	1,146.00
Blooming Prairie, (Depot)	1,185.76
One-half mile S. E. of Aurora, (Bottom of marsh)	1,106.56
One-half mile S. E. of Aurora, (Grade)	1,114,56
Aurora Station. Sec. 17, Aurora Township	1,150.66
Havana. S. W. ¼ sec. 31	1,118,62
Top of divide between Havana and Owatonna. Sec. 24, (Grade and natural surface)	1,141.06
Winona and St. Peter Crossing. Owatonna	1,041.56
Owatonna, (Depot)	1,041.56

	Above the Ocean.
	Feet.
Maple Creek, (Grade)	1,028.46
Maple Creek, (Bottom)	1,012.06
Clinton Divide. Section 21, ½ mile South of road-crossing, (cut 2 feet)	1,007.56
Medford	997.08
Straight River, (Grade)	986.40
Straight River, (Bottom)	958.06
Divide in Wolcott. S. W. ¼ sec. 19, (Natural surface)	1,051.06
Divide in Wolcott. S. W. ¼ sec. 19, (Grade)	1,084.06
Faribault	998.06
Cannon River, (Grade)	966.71
Cannon River, (Bottom)	948.56
Divide in Cannon City Township. N. E. ¼ sec. 24, (Natural surface)	1,039.06
Divide in Cannon City Township. N. E. ¼ sec. 24, (Grade)	1,007.06
Bottom of swamp, five miles N. of Faribault	961.56
Five miles N. of Faribault, (Grade)	998.06
Divide, S. W. ¼ sec. 31. Bidgewater, (Natural surface)	1,086.56
Divide, S. W. ¼ sec. 31. Bridgewater, (Grade)	1,027.56
Wolf Creek, (Grade)	964.56
Wolf Creek, (Bottom)	986.06
Dundas. Depot	945.71
Spring Creek, 1¾ miles S. W. of Northfield, (Grade)	907.06
Spring Creek, 1¾ miles S. W. of Northfield, (Bottom)	894.00
Heath Creek, (Grade),	912.06
Heath Creek, (Bottom)	894.56
Northfield. Depot	905.71
S. end of Plateau, 2 ms. N. of Northfield, (Nat. sur.) Sec. 19, Waterford.	972.06
S. end of Plateau, 2 ms. N. of Northfield, (Grade)	960.06
N. end of Plateau, 3 ms. N of Northfield, (Nat. sur.)	969.06
N. end of Plateau, 3 ms. N, of Northfield, (Grade)	959.06
Foot of slope, near Chub Creek, (Grade and nat. sur.)	918.06
Foot of slope, 5 miles from Northfield, (Natural Surface)	910.06
Foot of slope, 5 miles from Northfield, (Grade)	913.06
Castle Rock Depot	925.76
Divide, sec. 18, Castle Rock Tp., (Natural Surface)	1,004.46
Divide, sec. 18, Castle Rock Tp., (Grade)	998.56
Divide, one mile south of Farmington, (Natural Surface)	904.31
Divide, one mile south of Farmington, (Grade)	893.31
Farmington	894.09
Farmington, Crossing H. & D. R. R	891.31
Vermillion River Crossing, (Bottom)	879.06
Vermillion River Crossing, (Grade.) Rolling surface to—	888.06
Rosemont Depot. Rolling surface to—	950.06
Westcott Station	873.06
St. Paul Junction (at Mendota)	749.90
Crossing of the St. Paul & Sioux City R. R., Mendota	728.40
Mendota Junction.	712.40
Crossing of the Minesota River. Fort Snelling	708.48
Crossing of the Minnesota River, (Bottom)	662.60
Fort Snelling Station	712.50
Minnehaha Station	802.80
Minnehaha Creek (grade)	806.20
Minnehaha Creek (bottom)	792.10
Minneapolis Depot	816.00

McGregor Division.

	Above the Ocean.
	Feet.
State Line, near Le Roy, Mower county (Nat. Sur. and Grade)	1,163.47
Le Loy Depot	1,180.57
Divide, section 28, Le Roy, (Natural Surface)	1,205.47
Creek 2¼ miles west of Le Roy (Grade)	1,185.67
Creek, 2¼ miles west of Le Roy (Bottom)	1,167.97
Creek, 2¾ miles west of Le Roy (Grade)	1,185.67
Creek, 2¾ miles west of Le Roy (Bottom)	1,170.47
Taopi, (formerly Bellevue) section 16, Lodi (Grade)	1,236.47
Divide, ⅛ mile west of Taopi section 17 (Natural Surface)	1,245.47
Divide, ⅛ mile west of Taopi section 17 (Grade)	1,243.47
Adams, (Grade)	1,176.47
Creek, ¼ mile west of Adams, (Grade)	1,174.47
Creek, ¼ mile west of Adams, (Bottom)	1,159.47
Little Cedar river crossing (Grade)	1,172.47
Little Cedar river crossing (Bottom)	1,152.47
Divide, ¾ mile west of the Little Cedar (Natural Surface)	1,208.47
Divide, ¾ mile west of the Little Cedar (Grade)	1,201.17
Rose Creek Station	1,144.97
Rose Creek Crossing, (Grade)	1,136.47
Rose Creek Crossing, (Bottom)	1,122.47

River Division.

Low water at St. Paul	672.84
Grade of the L. S. & M. R. R., St. Paul, (near the old warehouse on the trestle work)	692.84
Dayton's Bluff, St. Paul, (Grade of R. R.)	696.34
Newport Station	737.87
Langdon	799.84
Hastings Depot, (Junction H. & D. R. R.)	696.31
Etter	677.84
Red Wing	673.84
Frontenac	707.34
Lake City	691.84
Reed's Landing	669.34
Wabasha	699.24
Kellogg	689.09
Weaver	660.84
Minneiska	659.44
Minnesota City	664.44
Crossing of the Winona & St. Peter R. R. (St. Peter Junction)	662.92
Winona	649.44
Homer	650.54
La Moille	647.44
Richmond	660.94
Dakota	644.44
Dresbach	663.44
La Crescent lime kiln, N. side of Houston county (Grade)	637.44

Hastings and Dakota R. R.

	Above the Ocean.
	Feet.
Hastings. Junction with the River Division Mil. & St. P. R. R.	696.81
Edge of prairie 3 miles W. of Hastings, Sec. 5, Marshan, (Grade and Nat. Surf.)	814.81
Thence slightly rolling surface, or nearly level, to—	
Nine and a half miles W. of Hastings, (Grade)	814.81
Nine and a half miles W. of Hastings, (Nat. Sur.)	822.81
Auburn	848.81
Sec. 27, Empire. Change of grade, (Nat. Sur.)	877.81
Sec. 27, Empire. Change of grade, (Grade)	876.81
Farmington, Crossing of the I. and M. Division	891.81
Fairfield, (Lakeville)	930.81
26½ miles from Hastings, (Nat. Surface)	1,079.81
26½ miles from Hastings, (Grade)	1,069.81
¾ mile E. of Prior Lake Station, (Natural Surface)	960.81
¾ mile E. of Prior Lake Station, (Grade)	948.81
Prior Lake Station	936.81
Prior Lake, (Surface of water)	896.81
Prior Lake Crossing, (Bottom)	871.81
Cut ½ mile W. of Prior Lake Crossing, (Nat. Surface)	952.81
Cut ½ mile W. of Prior Lake Crossing, (Grade)	926.81
Cut 3 miles W. of Prior Lake Station, (Nat. Surface)	915.81
Cut 3 miles W. of Prior Lake Station, (Grade)	890.81
8 miles W. of Prior Lake Station, (Nat. Surface)	749.81
8 miles W. of Prior Lake Station, (Grade)	750.81
Shakopee, Crossing of the Sioux City R. R.	742.81
Shakopee, Crossing of the Minnesota River, (Bottom)	657.81
Shakopee, Crossing of the Minnesota River, (Low water)	679.81
Shakopee, Crossing of the Minnesota River, (High water)	706.41
[Extreme range of water, 27.1 feet.]	
Shakopee, Crossing of the Minnesota River, (Grade)	714.81
Chaska depot	715.21
Chaska, Crossing of the Minneapolis and St. Louis R. R	716 81
Carver depot	802.11
Carver, Crossing of highway ¼ m. W. of depot, (Ravine, Bottom of)	786.81
Carver, Crossing of highway ¼ m. W. of Depot, (Grade)	805.00
Dahlgren, (Grade)	968.81
Dahlgren Station, (Nat. Surface)	975.81
Divide ½ m. W. of Dahlgren Station, (Nat. Surface)	976.81
Divide ½ m. W. of Dahlgren, (Grade)	970.81
Carver Creek crossing, (Bottom)	895.81
Carver Creek crossing, (Grade)	917.81
Benton Station, Divide, (Natural Surface)	943.81
Benton Station, Divide, (Grade)	934.81
Divide ¾ m. W. of Bonngard's Crossing, (Nat. Surface)	987.81
Divide ¾ m. W. of Bonngard's Crossing, (Grade)	978.81
Young America	977.81
Tiger Lake, Sec. 16, (Surface of water)	966.81
Divide 3½ miles W. of Young America; ½ m. E. of County Line, (Nat. Surface)	997.81
Divide 3½ ms. W. of Young America; ½ m. E. of Co. Line, (Grade)	991.81
Buffalo Creek Crossing, (Bottom)	953.81
Buffalo Creek Crossing, (Grade)	970.00
Divide ½ mile E. of Glencoe, (Nat. Surface)	1,018.81
Divide ½ mile E. of Glencoe, (Grade)	1,008.81
Glencoe Depot	990.01

Hasting and Dakota R. R. west of Glencoe, as surveyed in 1871 by F. A. Kimball, commencing on the range line between 30 and 31, at Round Grove, eighteen miles west of Glencoe.* From J. T. Dodge.

	Above the Ocean.
	Feet.
Glencoe Depot. Station 2,464.50	990.01
Nearly level to	
Station, 3,407	1,036.31
" 3,460	1,046.31
" 3,500	1,056.03
" 3,510	1,046.03
" 3,560	1,061.03
" 3,570	1,064.00
" 3,585	1,052.00
" 3,600	1,066.00
" 3,625	1,059.00
" 3,645	1,068.00
" 3,655	1,055.00
" 3,680	1,066.00
" 3,693	1,056.00
" 3,710	1,069.00
" 3,725	1,058.00
" 3,780	1,058.00
" 3,840	1,060.00
" 3,866	1,088.00
" 3,880	1,071.00
" 4,000	1,071.00
" 4,100	1,082.00
" 4,140	1,067.00
(Undulations 5-10 feet.)	
" 4,300	1,072.00
" 4,390	1,083.00
" 4,400	1,072.00
" 4,500	1,086.00
" 4,600	1,089.00
" 4,610	1,079.00
" 4,663	1,094.00
" 4,706	1,070.00
" 4,720	1,082.00
" 4,740	1,068.00
" 4,762	1,074.00
" 4,774	1,060.00
" 4,780	1,074 00
" 4,802 (E. Fork of Beaver Creek)	1,036.00
" 4,820	1,060.00
" 4,860	1,071.00
" 4,870	1,060.00
" 4,940	1,051.00
" 4,980 (W. Fork of Beaver Creek)	1,021.00
" 4,992	1,049.00
" 5,030	1,047.00
" 5,100	1,045.00
" 5,140 In N. E. ¼ Sec. 26, 115-36	1,047.00
" 5,160	1,041.00
" 5,165	1,056.00
" 5,170	1,045.00
" 5,190	1,046.00

* From Round Grove to Beaver Creek the survey was nearly in a due west course. From Hawk Creek to Big Stone Lake it ran from four to six miles north of the Minnesota River.

	Above the Ocean.
	Feet.
Station, 5,230	1,057.00
" 5,260	1,072.00
" 5,300	1,056.00
(Undulations of 15 feet.)	
" 5,300	1,043.00
" 5,420 (Sec. 13-18, R. 37-36.)	1,042.00
(Undulations.)	
" 5,460	1,022.00
" 5,490	1,046.00
" 5,570	1,056.00
" 5,610	1,041.00
(Undulations between 1,036 and 1,051.)	
" 5,740	1,031.00
" 5,750	1,026.00
" 5,760	1,038.00
" 5,790	1,048.00
" 5,810	1,031.00
" 5,830	1,039.00
" 5,900	1,026.00
" 5,930	1,038.00
" 5,947	1,023.00
" 5,970	1,036.00
" 6,020	988.00
" 6,023 (Hawk Creek)	970.00
" 6,030	999.00
" 6,040	1,007.00
" 6,090	1,009.00
" 6,094	1,010.00
" 6,096 (Creek)	989.00
" 6,100	1,008.00
" 6,140	1,012.00
" 6,142	996.00
" 6,145	1,012.00
" 6,230	1,031 00
" 6,315	1,010.00
" 6,340	1,018.00
" 6,400	1,004.00
" 6,417	988.00
" 6,460	1,021.00
(Undulating 5-10 feet.)	
" 6,600	1,014.00
" 6,625	985.00
" 6,660	997.00
" 6,672	988.00
" 6,730	1,008.00
" 6,770	987.00
" 6,820	1,000.00
" 6,824	1,001.00
" 6,826	980.00
" 6,828	996.00
" 6,850	980.00
" 6,870	970.00
" 6,880	983.00
" 6,910	978.00
" 6,930	941.00
" 6,960	959.00
" 6,968 (R. 40-41, Sec. 31-36.)	959.00
" 6,990	934.00

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		Above the Ocean.
		Feet.
Station,	7,070	931.00
"	7,090	925.00
"	7,149	928.00
"	7,150 (Chippewa River)	913.00
"	7,154	931.00
"	7,260	918.00
"	7,320	934.00
"	7,350	915.00
"	7,370	918.00
"	7,390	933.00
"	7,403	925.00
"	7,405	940.00
"	7,415	932.00
"	7,426	950.00
"	7,432	941.00
"	7,490	968.00
"	7,590	974.00
"	7,603	991.00
"	7,630	986.00
"	7,645	969.00
"	7,690	977.00
"	7,790	980.00
"	7,860	997.00
"	7,910	981.00
"	8,030	986.00
"	8,039 (Pomme de Terre River)	960 00
"	8,050	985.00
"	8,120	994.00
"	8,240	1,000.00
"	8,310	986.00
"	8,370	996.00
"	8,390	1,017.00
"	8,420	1,018.00
"	8,480	987.00
"	8,500	985.00
"	8.560	991.00
"	8,580	986.00
"	8,640	1,002.00
"	8,700	1,012.00
"	8,800	1,017.00
"	8,850	1,038.00
"	8,880	1,012.00
"	8,930	1,015.00
"	8,970	1,018.00
"	8,994-5	973.00
"	8,998-9,000	990.00
"	9,003. (Creek)	965.00
"	9,008	1,011.00
"	9,030	1,017.00
"	9,060, (Sec. 13, 121.46)	1,006.00
"	9,100	1,041.00
"	9,110	1,044.00
"	9,140	1,068.00
	(Undulations, 10-15 feet.)	
"	9,170	1,072.00
"	9,190	1,079.00
"	9,200, (Opposite foot of Big Stone Lake, 1½ ms. SE. of it)	1,077.00
	Big Stone Lake, opposite Sta. 9,316	938.50

REPORT ON THE GENERAL MUSEUM.

CONTAINING THE COLLECTIONS OF THE GEOLOGICAL AND NATURAL HISTORY SURVEY FOR 1875.

BY N. H. WINCHELL, CURATOR.

The Museum of the State University, at Minneapolis, is designed to exemplify to the people of the State the natural resources of the State of Minnesota, so far as the same are covered by the investigations ordered by the law creating a geological and natural history survey. It is also designed to afford to the students who may avail themselves of the instruction offered by the University, the means of illustration needed in the study of the Natural Sciences. In addition to the collections directly made by the survey, the law orders a system of exchanging with other institutions with a view of so augmenting the number of specimens on exhibition as to comprise finally a tolerably complete series of the different species and objects of interest and curiosity that are afforded by the Natural Sciences.

Prior to the commencement of the Geological and Natural History survey, there was a nucleus of a museum already in existence in the University. This comprised a variety of objects, many from the State of Minnesota, and others from foreign localities. The collections that have accumulated since the survey began have been withheld necessarily from exhibition owing to the lack of suitable room with proper cases and furniture for their exhibition and preservation. During the past year, however, the new University building having been substantially completed, room has been set aside for the museum, and a set of cases are rapidly approaching

completion, suitable for the reception of some, if not all, of the collections that belong to the museum.

The mammals that were collected in the Black Hills, mentioned in the last statement on the condition of the museum, have been mounted by Prof. H. A. Ward, of Rochester, New York, and are only awaiting the arrangement of the room to be set up in the University. They comprise antelope, male and female, deer with young, elk, elk head, badger, grizzly bear with young, and weasel. The moose which was secured last winter has also been mounted by Prof. Ward, and for the same reason is not on exhibition. It is kindly kept in store by Prof. Ward till our rooms are ready. This fine specimen was killed in December, 1874, by Peter Young, ("Wild Pete,") in the east part of Otter Tail county, on the north end of Parker's Prairie, after having been pursued about five miles. He was seen about a mile away, coming toward the hunter, on a trot, and passed within six rods of him. The first shot put a ball through his throat, but it required four or five more to bring him down. He was billed as freight to St. Paul, after the entrails were removed, with a weight of 590 pounds. His flesh and bones, without the neck and lower leg-bones, weighed 465 pounds. The specimen, as mounted, is pronounced one of rare size and perfection. In procuring and caring for this moose, before he was sent to Prof. Ward, Messrs. Wm. A. Van Slyke and Merrill Ryder, both of St. Paul, rendered much assistance.

In August the generosity of a few citizens of Minneapolis aided the Board of Regents to make the purchase of a fine set of Prof. Ward's casts. These are in plaster of paris, and are of life size, and will give the rooms assigned to the Museum a very attractive appearance. The contributors to this fund were the following gentlemen:

Judge E. S. Jones	$50 00
Gov. J. S. Pillsbury	150 00
Hon. L. Butler	150 00
Dr. H. H. Kimball	10 00
R. J. Mendenhall	10 00
Hon. E. M. Wilson	10 00
Hon. R. B. Langdon	50 00
Hon. H. T. Welles	50 00
S. C. Gale, Esq	25 00
Chute Brothers	10 00
Judge Isaac Atwater	15 00
D. S. Story	5 00
Jonathan Chase	100 00

Anthony Kelly	5 00
Wyman Elliott	5 00
Thomas Lowry	25 00
Hon. A. M. Reid	25 00
Hon. Paris Gibson	25 00

The full cost of the set was $1,500. It embraces the following specimens:

LIST OF WARD'S CASTS OF FOSSILS IN THE UNIVERSITY MUSEUM.

VERTEBRATA.

MAMMALIA.

[NOTE.—The numbers prefixed are those of Prof. Ward's Catalogue.]

2. Homo.................................... Engis Cavern, Belgium.
Pleistocene.

4. Homo...Guadaloupe.
Modern Concretionary Limestone.

4. (C.L.) Mesopithecus Pentelici. *Wagner*.............Pikermi, Greece
Upper Miocene.

7. (C. L.) Machairodus cultridens. *Cuv*................Pikermi, Greece.
Upper Miocene.

11. Hyæna eximia. *Wagner*..........................Pikermi, Greece.
Pleistocene.

15. Amphicyon major. *Lartet*......................Sansans, S. France.
Miocene Tertiary.

16. Ursus spelæus. *Blum*, (skull.)........Cave of Gallerneuth, Bavaria.
Quaternary.

17. Ursus spelæus. *Blum*, (pair of molars). Cave of Gailenreuth, Bavaria.
Quaternary.

18. Ursus spelæus. *Blum*. (canine tooth.)..Cave of Gailenreuth, Bavaria.
Quaternary.

19. Gulo spelæus. *Goldf*...............Cave of Gailenreuth, Bavaria.
Quarternary.

20. Trogontherium Cuvieri. *Fisch*....................Ostend, England.
Pliocene Tertiary.

21. Castoroides Ohioensis. *Foster*.......................Clyde, N. Y.
Pleistocene.

23. Megatherium Cuvieri. *Desm*................. Buenos Ayres, S. A.
Pampean Formation.

26. **Megatherium Cuvieri.** *Desm.* (tooth.).. ......Buenos Ayres, S. A.
Pleistocene.

34. **Megalonyx Jeffersonii.** *Harlan*.....................Henderson, Ky.
Pleistocene.

35. **Megalonyx Jeffersonii.** *Harlan*...............Cave, West Virginia.
Pleistocene.

36. **Glyptodon typus.** *Nodat*..........Pampean Deposit, Buenos Ayres.
Pleistocene.

41. **Glyptodon reticulatus.** *Owen.* (caudal armor.)......Buenos Ayres.
Pleistocene.

43. **Glyptodon clavipes.** *Owen.* (reduced.)...............Buenos Ayres.
Pleistocene.

54. **Bootherium cavifrons.** *Leidy*.........Ft. Gibson, Indian Territory.
Pleistocene.

55. **Bootherum bombifrons.** *Leidy*..................Big-bone Lick, Ky.
Pleistocene.

57. **Oreodon Culbertsonii.** *Leidy*...............Mauvaises Terres, Neb.
Miocene Tertiary.

59. **Anoplotherium commune.** *Cuv*..................Montmatre, Paris.
Eocene Gypsum.

60. **Anoplotherium commune.** *Cuv.* (right forefoot)..Montmatre, Paris.
Eocene Tertiary.

61. **Anoplotherium commune.** *Cuv.* (left hindfoot)...Montmatre, Paris.
Eocene Tertiary.

69. **Chœropotamus Parisiensis.** *Aym.* (skull).........Montmatre, Paris.
Eocene Tertiary.

71. **Anthracotherium magnum.** *Cuv*.................Auvergne, France.
Miocene Tertiary.

72. **Lophiochaerus splendens**.........................St. Albans, France.
Miocene Tertiary.

73. **Hippohyus Sivalensis.** *Falc. and Caut*.........Sewalik Hills, India.
Miocene Tertiary.

78. **Hippopotamus major.** *Cuv.* (right tusk.)

79. **Hippopotamus major.** *Cuv.* (left hindfoot).......Auvergne, France.
Pliocene Tertiary.

80. **Equus namadicus.** *Falc. and Caut*.............Sewalik Hills, India.
Miocene Tertiary.

83. **Hipparion elegans.** *Christol*.....................Concurron, France.
Lower Pliocene.

87. **Anchitherium Aurelianense.** *Gerv*................St. Alban, France.
Upper Miocene.

89. Rhinoceros platyrhinus. *Falc. and Caut.* ....Sewalik Hills, Ind.
Miocene.

90. Rhinoceros palæindicus. *Falc. and Caut.*.......Sewalik Hills, India.
Miocene Tertiary.

95. Rhinoceros pleuroceros, (lower jaw)................Gannat, France.
Miocene Tertiary.

99. Rhinoceros Merkii. *Kaup*..................Steinheim, Wirtemberg.
Miocene Tertiary.

100. Rhinoceros incisivus. *Cuv.*, (upper incisor).. .....Steinheim, Ger.
Miocene Tertiary.

102. Tapirus Avernensis. *Croiz and Job*......Auvergne, Central France.
Pliocene Tertiary.

103. Tapirus Avernensis. *Croiz. and Job*............. Auvergne, France.
Plocine.

104. Lophiodon Parisiense. *Gerv*..........................Paris, France.
Eocene Tertiary.

105. Pliolophus vulpiceps. *Owen*...............................England.
London Clay (Eocene.)

106. Palæotherium crassum. *Cuv*........................Montmartre, Paris.
Eocene Gypsum.

109. Palæotherium crassum. *Cuv*....................Monturartre, Paris.
Eocene Gypsum.

111. Palæotherium crassum. *Cuv.*, (left hind foot)........Paris, France.
Eocene Tertiary.

113. Dinotherium giganteum. *Kaup*..........Eppelsheim, Rhine Valley.
Miocene Tertiary.

118. Dinotherium levius, (upper jaw, left ramus)......St. Albans, France.
Miocene Tertiary.

119. Dinotherium levius, (upper jaw).................St. Albans, France.
Miocene Tertiary.

124. Dinotherium giganteum. *Kaup*..........St. Jean le Vieux, France.
Miocene Tertiary.

132. Elephas primigenius. *Blum*.........................Lippe, Prussia.
Pleistocene.

133. Elephas primigenius. *Blum*..................Dept. of Ain, France.
Pleistocene.

136. Elephas intermedius, (molar.).................River Saone, France.
Pleistocene.

137. Elephas intermedius, (molar.)..................St. Germain, France.
Pleistocene.

138. Elephas meridionalis. *Nesti*..................Basses Alpes, France.
Pliocene Tertiary.

142. Elephas Americanus. *Dekay*...........Homer, Cortland Co., N. Y.
Pleistocene.

143. Elephas Americanus. *DeKay*.................St. Catharines, C. W.
Pleistocene.

155. Mastodon giganteus. *Cuv*. (molar).............Big Bone Lick, Ky.
Pleistocene.

159. Mastodon longirostris. *Kaup*. (molar).............Lyons, France.
Miocene Tertiary.

169. Mastodon longirostris. *Kaup*. (tusk of lower jaw)...Lyons, France.
Miocene Tertiary.

171. Mastodon giganteus. *Cuv*...................St. Catharines, C. W.
Pleistocene.

176. Zeuglodon cetoides. *Owen*. (two teeth).............Claiborne, Ala.
Eocene Tertiary.

178. Rhizoprion Schinzi, (head.).......................Central France.
Miocene Tertiary.

179. Balaenodon gibbosus. *Ow*. (tympanic bones).....Suffolk, England.
Pliocene Tertiary.

181. Diprotodon Australis. *Owen*.............Darling Downs, Australia.
Pleistocene.

AVES.

184. Didus ineptus, (head)..................................Mauritius.
Alluvium.

186. Æpiornis maximus. *St. Hil*. (egg).................Madagascar.
Pleistocene.

186. Æpiornis maximus. *St. Hil*. (metatarsal)...............Madagascar.
Pleistocene.

188. Palapteryx ingens. *Ow*. (right foot)..................New Zealand.
Pleistocene.

189. Brontozooum gigantum. *Hitch*. (tracks).......Northampton, Mass.
Lias.

192. Brontozooum Sillimanium. *Hk*. (tracks)........Middletown, Conn.
Lias.

REPTILIA.

196. Polemarchus gigas. *Hk*. (track)..............Chicopee Falls, Mass.
Lias.?

149. (C. L.) Iguanodon Mantelli. *Meyer*..................Isle of Wight.
Wealden.

211. Ichthyosaurus communis. *Conyb*............Lyme-Regis, England.
Lias.

212. Ichthyosaurus communis. *Conyb.* (head).....Barrow-on-Soar, Eng.
Lias.

213. Ichthyosaurus communis. *Conyb.* (head)........Lyme-Regis, Eng.
Lias.

214. Ichthyosaurus communis. *Conyb.* (paddle)......Boll, Wirtemberg.
Lias.

219. Ichthyosaurus platyodon. *Conyb.*................Lyme-Regis, Eng.
Lias.

220. Ichthyosaurus tenuirostris. *Conyb*..............Boll, Wirtemberg.
Lias.

222. Ichthyosaurus tenuirostris. *Conyb*.............Boll, Wirtemberg.
Lias.

225. Plesiosaurus dolichodeirus. *Conyb*...............Glastonbury, Eng.
Lias.

227. Plesiosaurus macrocephalus. *Conyb*..............Lyme-Regis, Eng.
Lias.

231. Pliosaurus brachydeirus. *Owen.*, (paddle).........Dorchester, Eng.
Upper Oolite.

233. Pliosaurus grandis. *Owen*, (tooth)................Dorchester, Eng.
Upper Oolite.

237. Placodus gigas. *Agass*..........................Laineck, Bavaria.
Muschelkalk (Trias.)

239. Placodus gigas. *Agass*..........................Laineck, Bavaria.
Muschelkalk (Trias.)

241. Pterodactylus crassirostris. *Goldf*.............Solenhofen, Bavaria.
Upper Oolite.

242. Pterodactylus rhamphastinus. *Wagner*........Solenhofen, Bavaria.
Middle Oolite.

247. Crocodilus biporcatus. *Cuv.* (head)............Sewalik Hills, India.
Miocene Tertiary.

249. Crocodileimus robustus......................Dept. of Ain, France.
Upper Oolite.

251. Aligatorellus Beaumontii.....................Dept. of Ain, France.
Middle Oolite.

253. Teleosaurus Mandelslohi. *Bronn*.........Holzmaden, Wirtemberg.
Lias.

255. Teleosaurus longipes. *Bronn*..................Boll, Wirtemberg.
Lias.

256. Teleosaurus Cadomensis. *St. Hil.* (ventral scales)....Caen, France.
Lower Oolite.

262. Mosasaurus Hoffmanni. *Mantell*................Maestricht, Holland.
Upper Chalk.

268. Homœosaurus Maximiliani. *Meyer*................Kelheim, Bavaria.
Middle Oolite.

270. Saphæosaurus laticeps. *Meyer*...................Kelheim, Bavaria.
Middle Oolite.

277. Sauranodon incisivus.......................Dept. of Ain, France.
Middle Oolite.

278. Dicynodon lacerticeps. *Owen*.........Fort Beaufort, Cape Colony.
Trias.

281. Testudo hemispherica. *Leidy*.........Mauvaises Terres, Nebraska.
Miocene Tertiary.

285. Pleurosternon ovatum. *Owen*................Swanage, England.
Upper Oolite.

286. Chelonemys ovata, (ventral surface.).................Cirin, France.
Middle Oolite.

287. Chelonemys plana, (ventral surface.)..................Cirin, France.
Middle Oolite.

289. Hydropelta Meyeri. *D'Orb*.........................Cirin, France.
Middle Oolite.

292. Labyrinthodon Jægeri. *Owen*.............Stuttgardt, Wirtemberg.
Keuper (Trias.)

297. Andrias Scheuchzeri, *Tschudi*...............Œningen, Switzerland.
Miocene Tertiary.

298. Andrias Tschudi. *Meyer*.......................Rott, Rhine Valley.
Miocene Tertiary.

225. (C. L.) Cheirotherium Barthi. *Kaup*.............Jena, Germany.
Lower Trias (New Red Sandstone.)

299. Rana diluviana. *Goldf*........................Bonn, Rhine Valley.
Miocene Tertiary.

302. Pterodactyle (restored.)...........................Kent, England.
Chalk.

303 Megalosaurus, (restored.)...............Oxfordshire, etc., England.
Oolite.

304. Iguanodon, (restored.)..................Sussex and Kent, England.
Wealden.

305. Labyrinthodon, (restored.) ....Cheshire, England.
Trias.

306. Icthyosaurus, (restored.).............Somersetshire, etc., England.
Lias.

307. Plesiosaurus macrocephalus. *Conyb.* (restored.)...Dorsetshire, etc., England.
Lias.

808. Plesiosaurus dolichodeirus. *Conyb.* (Restored.)...Somersetshire, etc., England.
Lias.

PISCES.

809. Holoptychius nobilissimus. *Agass*...........Clashbinnie, Scotland.
Old Red Sandstone.

813. Cephalaspis Lyelli. *Agass*...................Forfarshire, Scotland.
Old Red Sandstone.

815. Lepidotus maximus. *Wagn*..................Solenhofen, Bavaria.
Upper Oolite.

816. Lepidotus oblongus. *Agass*.................Solenhofen, Bavaria.
Middle Oolite.

817. Lepidotus minor. *Agass*................Isle of Portland, England.
Upper Oolite.

820. Microdon (Pycnodus) elegans. *Agass*............Kelheim, Bavaria.
Upper Oolite.

821. Microdon notabilis. *Munst*......................Kelheim, Bavaria.
Middle Oolite.

824. Gyrodus circularis. *Agass*....................Solenhofen, Bavaria.
Upper Oolite.

828. Megalurus lepidotus. *Agass*.................Solenhofen, Bavaria.
Lithographic Slate (Upper Oolite.)

830. Squatina acanthoderma. *Fraas*......................Eichsädt, Bav.
Upper Oolite.

831. Thaumas alifer. *Munst*.........................Eicshtadt, Bavaria.
Middle Oolite.

833. Carcharodon.......................................Isle of Malta.
Miocene.

836. Acrodus nobilis. *Agass*........................Lyme-Regis, Eng.
Lias.

838. Plycodus decurrens. *Agass*............................Kent, Eng.
Chalk.

842. Mesturus verrucosus. *Wagner*................Eichstadt, Bavaria,
Middle Oolite.

844. Ichthyodorulite, (dorsal spine)..................Lyme-Regis, Eng.
Lias.

847. Holocentrum pygæum. *Agass*..................Monte Bolca, Italy.
Eocene Tertiary.

1201. Coprolite of Fish...................................Kent, Eng.
Lower Chalk.

ARTICULATA.

CRUSTACEA.

353. Enoploclytea Sussexiensis. *Mant.* (claw)..........Lewes, England.
Lower Chalk.

354. Eryon propinquus. *Germar*....................Eichstadt, Bavaria.
Upper Oolite.

358. Pemphyx Sueurii. *Meyer*.................Crailsheim, Wirtemberg.
Muschelkalk (Middle Trias.)

365. Limulus Walchii. *Desm*.........................Eichstadt, Bavaria.
Middle Oolite.

367. Euripterus lacustris. *Harlan*..................Williamsville, N. Y.
Waterlime Group, (Upper Silurian.)

368. Eurypterus lacustris. *Harlan*..................Williamsville, N. Y.
Waterlime Group, (Upper Silurian.)

372. Pterygotus Anglicus. *Agass*................Forfarshire, Scotland.
Old Red Sandstone.

373. Asaphus gigas. *Dalm.* (restored from fragments.)..Adams Co. Ohio.
Lower Silurian.

374. Asaphus gigas. *Dalm.* ....Cincinnati, Ohio.
Lower Silurian.

380. Asaphus expansus. *Dalm*........................Motala, Sweden.
Lower Silurian.

382. Asaphus tyrannus. *Murch*.................Bishop's Castle, Wales.
Llandeilo Flags. (L. Sil.)

384. Asaphus Barrandi. *Hall*..........................Platteville, Wis.
Trenton limestone, (L. Silurian.)

388. Angelina Sedgwicki. *McCoy*.........................Garth, Wales.
Lower Silurian.

390. Bumastus Barriensis. *Murch*...........................New York.
Niagara Group.

393. Bronteus planus. *Barr*.........................Beraun, Bohemia.
Upper Silurian.

394. Calymene Blumenbachii. *Brongniart*.............Dudley, England.
Upper Silurian.

395. Calymene Blumenbachii. *Brong*..................Dudley, England.
Upper Silurian.

396. Calymene senaria. *Conrad*.......................Cincinnati, Ohio.
Lower Silurian.

397. Calymene læviceps. *Dalm*.......................Motala, Sweden.
Lower Silurian.

398. Ceraurus pleurexanthemus. *Green.* (partially restored.)
Lower Silurian.

399. Ceraurus pleurexanthemus. *Green*..................Ottawa River.
Trenton limestone.

400. Chirurus claviger. *Beyr*..............................Wesela, Boh.
Lower Silurian.

401. Conocephalus Sulzeri. *Schloth*....................Ginetz, Bohemia.
Lower Silurian.

402. Cychaspis Chrystyi. *Hall*..........................Waldron, Ind
Niagara Group.

405. Dalmania calliteles. *Green*..........................York, N. Y.
Hamilton Group.

408. Dalmania micrurus. *Green*...............Schoharie county, N. Y.
Lower Helderberg.

411. Dalmania nasutus. *Conrad*...............Schoharie county, N. Y.
Lower Helderberg.

414. Dalmania selenurus. *Eaton*.........................Auburn, N. Y.
Upper Helderberg.

415. Dalmania socialis. *Barr*...............................Bohemia.
Lower Silurian.

417. Dindymene Bohemica. *Barr*..................Rokycan, Bohemia.
Lower Silurian.

421. Harpes ungula. *Barr*........................Kronieprus, Bohemia.
Upper Silurian.

422. Harpides Grimmi. *Barr*......................Przibram, Bohemia.
Lower Silurian.

423. Homalonotus delphinocephalus. *Murch*...........Dudley, England.
Upper Silurian.

428. Lichas Boltoni. *Green*..............................Lockport, N. Y.
Niagara Group.

429. Lichas grandis. *Hall.* (head.)..............Schoharie county, N. Y.
Schoharie Grit, (Devonian.)

430. Lichas grandis. *Hall.* (pygidium reversed.)....Schoharie Co., N. Y.
Schoharie Grit, (Devonian.)

433. Ogygia Buchii. *Goldf*..............................South Wales.
Lower Silurian.

436. Olenellus Thompsoni. *Hall*...........................Georgia, Vt.
Quebec Group, (Lower Silurian.)

437. Paradoxides Bohemicus. *Bock*...................Ginetz Bohemia.
Lower Silurian.

439. Pradoxides Davidis. *Salter*....................St. Davids, Wales.
Lower Silurian.

442. Phacops cephalotes. *Corda*........................Tetin, Bohemia.
Upper Silurian.

INSECTA.

451. Æchna eximia. *Hagen*.......................... .Solenhofen, Bav.
Lithographic Limestone, (Middle Oolite.)

ANNELIDA.

454. Vermetus gigas. *Biv*............ ....Asti, Piedmont.
Miocene Tertiary.

455. Tentaculites elongatus. *Hall*..................Schoharie Co. N. Y.
Lower Helderberg.

MOLLUSCA.

CEPHALOPODA.

456. Belemnites Oweni. *Pratt*, (guard)......Christian Malford, England.
Upper Oolite.

457. Belemnites Oweni. *Pratt*..............Christian Malford, England.
Upper Oolite.

458. Belemnites giganteus. *Schloth*...................Ehningen, Wirt.
Lias.

461. Belemnites acuarius. *Schloth*....................Whitby, England
Lias.

462. Belemnites lateralis. *Phil.* (guard.)................Yorkshire, Eng.
Cretaceous.

463. Beloteuthis subcostata. *Munst*....... ....Holzmaden, Wirt.
Lias.

467. Ammonites armatus. *Sow*........................Charmouth, Eng.
Lias.

468. Ammonites Aon. *Munst*.......................St. Cassian, Austria.
Trias.

472. Ammonites Batesi. *Trask*...................Shasta Co., California.
Cretaceous.

473. Ammonites bisulcatus. *Brug*..............Rautenberg, Brunswick.
Lower Lias.

475. Ammonites Blagdeni. *Sow*....................Dorsetshire, England.
Lower Oolite.

476. Ammonites Birchii. *Sow*....................Charmouth, England.
Lias.

477. Ammonites Bechei. *Sow*......................Charmouth, England.
Lias.

478. Ammonites Brongniarti. *Sow*......................Yeovil, England.
Lower Oolite.

484. Ammonites cordatus. *Sow*......................Calvados, France.
Middle Oolite.

485. Ammonites cordatus. *Sow*......................Calvados, France
Middle Oolite.

487. Ammonites coronatus. *Brug*......................Villere, France.
Middle Oolite.

490. Ammonites fimbriatus. *Sow*......................Charmouth, England.
Middle Lias.

491. Ammonites fimbriatus. *Sow*......................Charmouth, Eng.
Middle Lias.

492. Ammonites gigas. *Zieten*......................Yonne, France.
Upper Oolite.

495. Ammonites Goliathus. *D'Orb*......................Dives, France
Middle Oolite.

497. Ammonites Henleyi. *Sow*......................Charmouth, England.
Lias.

498. Ammonites Herveyi. *Sow*......................Wilts, England.
Middle Oolite.

500. Ammonites heterophyllus. *Sow*..........Reutlingen, Wirtemberg.
Lias.

501. Ammonites Humphriesianus. *Sow*..................Yeovil, England.
Lower Oolite.

502. Ammonites ——......................Calvados, France.
Middle Oolite.

503. Ammonites interruptus. *Brug*..............St. Florentin, France.
Cretaceous.

504. Ammonites interruptus, *Park*......................France.
Gault (Cretaceous).

505. Ammonites Jason. *Rein*..................Christian Malford, Eng.
Middle Oolite.

509. Ammonites linguiferus. *D'Orb*..................Calvados, France.
Lower Oolite.

511. Ammonites macrocephalus. *Schloth*............Wiltshire, England.
Middle Oolite.

515. Ammonites margaritatus. *Mum*...................Charmouth, Eng.
Lias.

518. Ammonites Millesianus. *D'Orb*......................Rouen, France.
Chalk.

519. Ammonites modiolaris. *Luid*..................Wiltshire, England.
Middle Oolite.

521. Ammonites obtusus. *Sow*....................Charmouth, England.
Lower Lias.

523. Ammonites peramplus. *Mant*..........................Germany.
Chalk.

525. Ammonites planicostatus. *Sow*..................Dorset, England.
Lias.

527. Ammonites raricostatus. *Ziet*...............Charmouth, England.
Lias.

529. Ammonites Rhotomagensis. *Brong*................Rouen, France.
Chalk.

531. Ammonites serpentinus. *Schloth*..............Boll, Wirtemberg.
Lias.

536. Ammonites Woollgari. *Mant*...................Sussex, England.
Chalk.

537. Ammonites Woollgari. *Mant*....................Sussex, England.
(Enlarged from 536.)

538. Ammonites gigas. *Ziet.* (Enlarged from 492.)......Yonne, France.
Upper Oolite.

539. Ancyloceras Andouli. *Astier*.....................Cheiron, France.
Cretaceous Greensand.

540. Ancyloceras Emerici. *D'Orb*...................Barreme, France.
Upper Neocomian, (Cretaceous)

541. Ancyloceras gigas. *Sow*................Atherfield, Isle of Wight.
Cretaceous Greensand.

543. Ancyloceras Tabarelli. *Astier*..................Barreme, France.
Cretaceous.

546. Baculites anceps. *Lam*................................France.
Chalk.

547. Ceratites nodosus. *DeHaan*...................Luneville, France.
Muschelkalk, (Trias.)

551. Crioceras bifurcatus. *Quenst*.............Reutlingen, Wirtemberg.
Jurassic.

552. Crioceras Duvalii. *Lev*......................Escragnolles, France.
Neocomian (Cretaceous.)

553. Goniatites expansus. *Vanux*......................Manlius, N. Y.
Goniatite limestone (Devonian.)

554. Goniatites ixion. *Hall*...........................Rockford, Ind.
Carboniferous.

555. Hamites attenuatus. *Sow*..................Folkestone, England.
Gault (Cretaceous.)

557. Hamites Astierianus. *D'Orb*..................... Barreme, France.
Neocomian (Cretaceous.)

558. Hamites (Hamulina) cinctus.) *D'Orb*.............. Barreme, France.
Upper Neocomian (Cretaceous.)

563. Scaphites Ivanii. *Pusos*......................... Barreme, France.
Lower Greensand.

564. Scaphites compressus. *Röm*.................. Haldem, Westphalia.
Chalk.

566. Toxoceras obliquatum. *D'Orb*................ Escragnolles, France.
Greensand (Cretaceous.)

567. Turrilites costatus. *Lam*........................... Rouen, France.
Chalk Marl (Lower Cretaceous.)

569. Nautilus bidorsatus. *Schloth*................. Brunswick, Germany.
Muschelkalk (Trias.)

573. Nautilus Neocomensis. *D'Orb*................ Escragnolles, France.
Neocomian (Cretaceous.)

574. Nautilus pseudo-elegans. *D'Orb*..................... Rouen, France.
Chalk.

575. Nautilus semistriatus. *D'Orb*..................... Charmouth, Eng.
Lias.

578. Nautilus ——................................. Charmouth, Eng.
Middle Lias.

579. Nautilus ——.. Kentucky.
Carboniferous ?

580. Lituites undatus. *Conrad*........................ Middleville, N. Y.
Black River limestone, (L. Sil.)

582. Discites ornatus. *Hall*.......................... Manlius, N. Y.
Goniatite limestone, (Devonian.)

585. Orthoceras amplicameratum. *Hall*.............. Middleville, N. Y.
Trenton Limestone, (Lower Silurian.)

586. Orthoceras crebrum. *Sæm*..................... Eifel, Rhine Valley.
Devonian.

587. Orthoceras inequale. *Barr*..................... Butowitz, Bohemia.
Upper Silurian.

592. Gomphoceras inflatum. *Quenst*............... Eifel, Rhine Valley.
Devonian.

597. Phragmoceras subventricosum. *D'A and De V*.. Eifel, Rhine Valley.
Devonian.

598. Cyrtoceras macrostomum. *Hall*.............. Mineral Point, Wis.
Trenton Limestone (L. Sil.)

599. Cyrtoceras corbulatum. *Barr*............................. Bohemia.
Upper Silurian.

600. Cyrtoceras elongatum. *Barr*....................Beraun, Bohemia.
Upper Silurian.

602. Gyroceras trivolvis. *Conrad*..............Schoharie county, N. Y.
Upper Helderberg, (Devonian.)

604. Gyroceras expansum. *Sœm*.................. ...Cazenovia, N Y.
Hamilton Group.

605. Gyroceras Eifelense. *D'Arch*.... ....Eifel, Rhine Valley.
Devonian.

GASTEROPODA.

608. Rostellaria carinata. *Mant*...... ....Folkestone, England.
Gault. (Cretaceous.)

609. Pyrula melongena. *Grateloup*.....................Saucats, France.
Miocene Tertiary.

611. Fusus longaevus. *Lam*...... ....Bracklesham, England.
Eocene Tertiary.

619. Cerithium giganteum. *Lam*................. ......Damery, France.
Eocene Tertiary.

620. Cerithium giganteum. *Lam*, (inner cast).......Vaugirard, France.
Eocene Tertiary.

621. Cerithium cornucopiæ. *Sow*..................Contentin, France.
Eocene Tertiary.

624. Euomphalus rugosus. *Sow*......................Dudley, England.
Upper Silurian.

633. Capulus elegans. *Barr*..................................Bohemia.
Upper Silurian.

634. Capulus robustus. *Barr*..... ....Zochkow, Bohemia.
Upper Silurian.

637. Dentalium Noe. *Bon*.... ....Astezan, Piedmont.
Pliocene Tertiary.

LAMELLIBRANCHIATA.

647. Ostrea frons. *Park*.................................Royan, France.
Chalk.

648. Ostrea Santonensis. *D'Orb*.......................Royan, France.
Chalk.

650. Gryphæa arcuata. *Lam*...........................Semur, France.
Lias.

651. Exogyra columba. *Goldf*.........................Boussa, France.
Cretaceous.

652. Exogyra costata. *Morton*.....................Perry Co., Alabama.
Cretaceous.

658. Radiolites crateriformis. *D'Orb*.......................Royan, France.
Chalk.

660. Sphærulites Bournoni. *Desm*.......................Dordonge, France.
Chalk.

661. Sphærulites calceoloides. *Desm*.................Dordogne, France.
Chalk.

663. Caprina adversa. *D'Orb*...........................Charente, France.
Chalk.

664. Avicula flabella. *Conrad*.......................Onondaga Co., N. Y.
Hamilton Group (Devonian.)

670. Pterinea radians. *Conrad*..........................Casenovia, N. Y.
Hamilton Group (Devonian.)

671. Posidonia alveata. *Conrad*.........................Sherburne, N. Y.
Hamilton Group (Devonian.)

672. Megambona cordiformis. *Hall*...............Onondaga Co., N. Y.
Corniferous Limestone (Devonian.)

675. Hippopodium ponderosum. *Sow*..................Cheltenham, Eng.
Lias.

679. Trigonia costata. *Park*..........................Œschingen, Wirt.
Lower Oolite.

683. Modiola plicata. *Sow*..............................Rendcomb, Eng.
Oolite.

686. Thracia —— ....Thebes, Egypt.
Cretaceous.

689. Teredina personata. *Lam*.....................Mt. Bernon, France.
Eocene Tertiary.

BRACHIOPODA.

690. Spirifer pinguis. *Sow*............................Dublin, Ireland.
Carboniferous limestone.

696. Spirifer oxypteris. *Burv*.........................Carignan, France.
Lias.

706. Terebratula grandis. *Blum*...................Bunde, Westphalia.
Miocene Tertiary.

716. Terebratula intermedia *Sow*.....................Calvados, France.
Lower Oolite.

755. Productus giganteus. *Martin*................Derbyshire, England.
Carboniferous.

RADIATA.

ECHINODERMATA.

762. Cidaris coronata. *Goldf*....................Nattheim, Wirtemberg.
Coral Crag (Middle Oolite.)

776. Hemicidaris intermedia. *Flem*..................Wiltshire, England.
Oolite.

781. Palaechinus multipora. *Nor. and O.*.................St. Louis, Mo.
St. Louis Limestone (Carboniferous.)

802. Echinobrissus clunicularis. *Blainv*...............Stroud, England.
Lower Oolite.

814. Clypaeaster umbrella. *Agass*.............................Sardinia.
Miocene Tertiary.

821. Discoidea cylindrica. *Agass*.......................Rouen, France.
Chalk Marl (Cretaceous.)

825. Galerites albo-galerus. *Lam*......................Kent, England.
Upper Chalk.

838. Dictyophyton tuberosum. *Hall*.............Steuben county, N. Y.
Chemung (Upper Devonian.)

842. Hemipneustes radiatus. *Agass*................Maestricht, Holland.
Upper Chalk.

847. Micraster cor-anguinum *Agass*....................Kent, England.
Chalk.

860. Ophioderma Egertoni. *Broderip*.............Lyme-Regis, England.
Lias.

861. Ophioderma Egertoni. *Brod*.....................Lyme-Regis, Eng.
Lias.

868. Solastor Moretonis. *Forbes*.............Gloucestershire, England.
Great Oolite.

898. Apiocrinus Parkinsoni. *Schloth*...................Bradford, Eng.
Great Oolite.

899. Apiocrinus Parkinsoni. *Schloth*...................Bradford, Eng.
Oolite.

901. Apiocrinus Parkinsoni. *Schloth*...................Bradford, Eng.
Oolite.

904. Astrocoma Cirini..................................Cirin, France.
Lithographic Limestone (Middle Oolite.)

911. Crotalocrinus rugosus. *Miller*...................Dudley, England.
Upper Silurian.

917. Encrinus liliiformis. *Schloth*................Brunswick, Germany.
Muschelkalk (Middle Trias.)

918. Encrinus liliiformis. *Schloth*.......................Brunswick, Ger.
Muschelkalk, (Trias.)

919. Encrinus liliiformis. *Schloth*.......................Brunswick, Ger.
Muschelkalk, (Trias.)

942. Pentacrinus subangularis. *Miller*.................Boll, Wirtemberg.
Lias.

943. Pentacrinus subangularis. *Miller*.................Boll, Wirtemberg.
Lias.

947. Periechocrinus moniliformis. *Miller*...................Dudley, Eng.
Upper Silurian.

953. Platycrinus Sarae. *Hall*.............................St. Louis, Mo.
St. Louis Limestone (Carboniferous.)

954. Pterocoma pinnata. *Agass*...................Solenhofen, Bavaria.
Middle Oolite.

ACALEPHAE.

963. Graptolithus octobrachiatus. *Hall*.
Lower Silurian.

PROTOZOA.

RHIZOPODA.

966. Amphistegina vulgaris. *D'Orb*...................Bordeaux, France.
Miocene Tertiary.

968. Fusulina cylindrica. *D'Orb*......................Ohio and Nebraska.
Carboniferous.

999. Cassidulina serrata.......................................Austria.
Miocene.

1002. Clavulina communis. *D'Orb*................ ...Nussdorf, Austria.
Pliocene.

1007. Globigerina bulloides. *D'Orb*.
Miocene; Austria.
Pliocene; Italy.
Living; Adriatic.

1015. Proroporus complanatus. *Reuss*.
Gault.

1036. Siderolina calcitrapoides. *Lam*...............Maestricht, Holland.
Chalk.

1039. Siphonina reticulata. *Reuss*..............................Germany.
Miocene.

1043. Textularia conulus. *Reuss.*
Upper Chalk.

1047. Textularia pupoides............................Meudon, France.
Upper Chalk.

1049. Textularia spinulosa. *Reuss*..............................Germany.
Miocene Tertiary.

1059. Cristellaria cassis. *Ficht*............................Sienna, Italy.
Pliocene.

1077. Globulina gibba. *D'Orb*..................France and Adriatic Sea.
Tertiary and Living.

1094. Nodosaria inflata. *Reuss.*
Upper Chalk.

1097. Nodosaria oblonga. *Reuss.*
Eocene Tertiary.

1098. Nodosaria radicula. *Lam.*
Gault (Cretaceous.)

1138. Orbitolites macropora. *Lam*..................Maestrict, Holland.
Chalk.

1150. Spirolina cylindrica. *Lam*.........................Paris, France.
Eocene Tertiary.

1161. Vertebralina nitida. *D'Orb*.....................Grignon, France.
Eocene Tertiary.

PORIFERA.

1164. Amorphospongia ——......................Franklin county, Ky.
Lower Silurian.

1165. Cœloptychium agaricoides. *Goldf*............Haldem, Westphalia.
Chalk.

1166. Placoscyphia meandroides. *Leym*..................Kent, England.
Cretaceous Greensand.

1168. Polypothecia dichotoma. *Ben*.............Warminster, England.
Cretaceous Greensand.

1172. Scyphia polyommata. *Goldf*.............Streitberg, Wirtemberg.
Middle Oolite.

1184. Siphonia costata. *Lam*.....................Warminster, England.
Cretaceous Greensand.

1177. Siphonia pyriformis. *Goldf*.................Blackdown, England.
Upper Greensand (Cretaceous.)

1185. Tentriculites ——........................Birdlington, England.
Chalk.

MISCELLANEOUS.

1204. Cycadoides megalophylla. *Buckl.* (Trunk of a short cycad. Isle of Portland, England.
Wealden.

1206. Dammarites ——, (conifer.).........Burton, Somerset, England.
Inferior Oolite.

1207. Nipadites Burtini. *Brong*....................Schaerbeck, Belgium.
Eocene Tertiary.

1212. Welcome Nugget (gold).........................Ballarat, Australia.

1216. Platinum Nugget...................................Ural Mts., Siberia.

1237. Rosetta Stone.................................Rosetta, Lower Egypt.

1245. Bust of Linnæus, life size.

1247. Bust of Cuvier, life size.

1248. Bust of Geoffroy St. Hilaire, life size.

Bust of Huxley, life size.

ERRATA.

Page 15, lines 3 and 4 from top, for vallies read *valleys*.
Page 15, line 14 from bottom, for Ttrenton read *Trenton*.
Page 33, line 9 from bottom, for continious read *continuous*.
Page 41, line 2 from bottom, after seen, insert *if restored*.
Page 51, line 6 from bottom, for McVee read *McNee*.
Page 53, line 13 from top, for M. read *A*.
Page 58, line 8 from bottom, for Shunard read *Shumard*.
Page 67, line 6 from top, for tickest read *thickest*.
Page 108, line 8 from top, for knoles read *knolls*.
Page 115, line 12 from top for characterzes read *characterizes*.

INDEX.